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ELECTRIC TRACTION PROBLEMS.

MANY of our readers will recollect the very complete tests made by Mr. A. Reckenzaun at Philadelphia in the year 1887, and published in our issues of July 6th and 13th last year. These were probably the first systematic tests carried out with electric cars in the United States, and the articles contained a summary of some 13,000 observations made on storage battery cars of his construction during the ordinary daily services in the streets of a busy city, where all the varying conditions of tramway traction come into play. Mr. Reckenzaun has shown in his "Notes" that the current at starting, and on steep inclines, rose to as much as 80 ampères, and that even on moderately level parts the variations, owing to frequent stoppages, slowing down and speeding up, were very marked. As an example, he cited the distance of 10 blocks of houses from Broad Street to Fourth Street, Philadelphia, traversing which showed the following mean current densities, viz.: 31·25, 21·05, 42·64, 8·26, 26·59, 0, 16·53, 41·66, 0, and 20·62 ampères respectively. The average, during an entire trip over 3½ miles, was 36 ampères with an E.M.F. of 157 volts, the approximate load of car and 40 passengers being 7 tons. The roads were in the usual dirty condition, weather dry, and the speed of the electric car had to be regulated to the horse traffic on the same line. Careful measurements were also taken of the energy used in charging the batteries at the station, and the densities of the electrolyte in the cells were ascertained before starting and after returning from a given number of trips.

The value of such exhaustive tests cannot be overestimated, for they give us a clear idea of the amount of energy required; they tell us the maximum power to be provided for, and are the means of bringing about improvements which cannot be arrived at by mere guesswork and rule of thumb blundering.

Following Mr. Reckenzaun's initiative, Dr. Louis Bell, of Purdue University, recently made similar tests with the electric cars at Lafayette, Indiana, on a road supplied with overhead conductors of the Sprague type. We reprint elsewhere Dr. Bell's interesting article, taken from the *Electrical World* of New York, in which the author states that he did not concern himself with theoretical motor tests and curves, but to actual tests of power and efficiency, and to the evidence of the ammeter and the indicator diagrams at the power station. "The man who contemplates putting his money into an electric road does not particularly care about the characteristic of the motor used, but he does want to know how much power must be developed on his cars, how much coal he must burn, what efficiency he may expect from the system, what are the weak points, and how they may be strengthened." The programme which Dr. Bell set to himself was carried out in a thoroughly practical manner, and we do not in the least doubt the accuracy of his figures, which are exceedingly instructive, and upon which we now offer a few comments and suggestions. The Lafayette Street Railway is 3·6 miles long, single track. At the time of the tests it had been in operation for about eight months. It has a grade of 7·34 per cent. for 100 feet, and one of 6·6 per cent. fully 800 feet long. There are about a dozen curves. Six cars are in continuous use; each of these seats 20 persons, and weighs complete 5,200 lbs. There are two Edison dynamos, each of the normal capacity of 30,000 watts, or rather more in case of need. The first car leaves the end of the road at 6.20 a.m., and the last car gets in at 10.20 p.m. Each car makes from 35 to 40 miles per day.

The mean indicated horse-power throughout the day was 39·05; the highest figure reached during the tests was 79·3 I.H.P. The mean electrical H.P. was estimated at 14·58, and the greatest output by the dynamos was 90 ampères at 410 volts, giving 49·46 electrical H.P. But it is observed that occasionally 75 electrical H.P. may be demanded. The ammeter readings frequently fell to zero for a few seconds at a time. Thus the current on the line varied from 0 to 90 ampères, and the E.M.F. from 405 to 480 volts. The coal burnt during the day was 4,500 lbs. of slack, which is at the rate of 7·3 lbs.

per I.H.P., or nearly 16 lbs. per electrical (estimated) H.P. "Combining the indicated horse-power at the engine with the estimated horse-power on the car line, and making proper allowance for power consumed in the lamps and on the stationary motor line, we have an average efficiency of the power station = 40·7 per cent. throughout the day, and for the maximum efficiency 65 per cent."

Fig. 1 gives the variations of the H.P. and efficiency throughout the day, and fig. 2 the variation of current as given by the five-minute readings between the hours of 10 and noon. Dr. Bell adds that "even this does not represent the real amount, for as a matter of fact, the current is never even approximately constant for more than a few seconds at a time, and varies from *nil* to 60 or 70 ampères, in a way that nothing but a continuous record can show. As a result of this, the mean output is, on a system of this size, less than 25 per cent. of the maximum, which may be called for, and must be furnished at any moment. As the system becomes larger, the ratio of mean to maximum output increases, until for a large system it may amount to one-half."

The figures given by Dr. Bell teach us two important lessons. At Lafayette the maximum work done is 240 car miles a day, with an average expenditure of 650 H.P. hours. This gives 2·6 H.P. hours per car mile, and is in excess of the energy expended on storage battery cars, although they weigh more, and occasion a loss of nearly 40 per cent. in conversion. The higher *average* efficiency of traction with storage batteries may be accounted for by the fact that the plant at the charging station is always running at its full power, whereas the fluctuations in the supply through conductors are very great, as will be readily seen by diagram fig. 2. Furthermore, the engine has to be as large, if not larger, with the overhead system, as with the accumulator system, to produce the same useful effect.

The second inference we draw from Dr. Bell's figures is, that in a system with conductors, where the average output is only 25 per cent. of the maximum, it would be wise to use a much smaller engine, in conjunction with a set of accumulators at the supply station, for steadying the work upon the prime mover and the dynamo, and thus have practically a constant load upon the central station plant. This has been advantageously introduced in electric lighting stations where the fluctuations are insignificant in comparison with those in an electric tramway system with overhead or other conductors. The addition of storage batteries on a line like the one at Layfayette would, without doubt, be found more economical and safer in the long run than a direct supply under such unfavourable conditions. Dr. Bell's article is full of interesting points, and some of his suggestions are worthy of a careful study on the part of those engaged on electric traction problems. He, however, lays all the stress of his arguments upon the employment of special steam engines to remedy the difficulty, and he recommends working the engine on the average at its most economical point of cut-off, while retaining the power of responding to sudden, though brief, demands for several times the average power. This, together with the suggested heavy fly-wheel, will not meet the demand, and the ideal method of steadying the work is, as we have said, by means of good accumulators.

ONCE more attention has been drawn in Parliament to the question of overhead wires, and once more the question has practically been shelved, although for the future electric light wires will be under restrictions. There seems to be a general impression that nothing will be done in the matter until some "great catastrophe," akin to the bursting of the Johnstown dam, takes place, though of the nature of the catastrophe, and why it should take place, there exists but the vaguest notion in the minds of those who form the idea. In spite of the prophesies of the most dire results, the erection of telephone and electric light wires goes on apace, and has gone on for some years, without serious results arising therefrom. Accidents, of course, have happened, and may happen, if careless work is done, and therefore a proper system of inspection of overhead wires is desirable; but that a wholesale disaster is likely to take place time has proved it, we think, to be improbable. From an æsthetic point of view, the removal out of sight of the network is much to be wished, and in many districts underground could be substituted for open work, though at a very heavy expense; but, unfortunately, it is not in such districts that the advisability of the substitution arises; it is where the wires are most crowded together that the disfigurement and danger are greatest, and it is here where it is least possible to adopt underground work, for in such districts the space under the pavement and roadways is already fairly choked with pipes of all kinds. To put down fresh pipes for telephone wires would be exceedingly difficult, but to utilise further the existing pipes belonging to the Postal Department, or to enlarge the same, would probably be practicable; such an arrangement, however, could only be carried out by the Government acquiring the telephone system, an arrangement which many consider very advisable, and one which will probably be considered when the time of expiry of the patents draws close.

WE notified a short time ago that the Edison Company had made a reduction in the prices of incandescent lamps, but it now appears that what on the face of the circular looked like a boon to the trade, is not so. The altered price carries with it a greatly reduced discount, so that in reality traders have now to pay more for lamps than they did previous to the issue of the new terms. Surely this shuffling with figures is neither dignified nor fair on the part of the company, and it is calculated to handicap the trade still more? What we require now that electric lighting prospects look somewhat more rosy is a real reduction of prices all round, or, at least, wherever possible, and not an advance under the guise of a benefit. This kind of thing is eminently suited to an enterprising draper who sells off somebody's bankrupt stock at an enormous sacrifice; but we had looked for a truer regard for its own interests in dealing comprehensively with the subject than the Edison Company appears to possess.

THE gas engine recently introduced by the Campbell Gas Engine Company, of Halifax, is said to have been tried very successfully for electric lighting, and three engines of this make are to be employed in connection with the lighting of the Electrical and Industrial Exhibition at Birmingham. Being simple in construction, the Campbell gas engine is cheap, suitable for hard and constant work, and requires little attention. There are no slides with their many objectionable features, such as constant wear and tear from friction, necessitating delicate adjustment and continual overhauling. As there is an ignition at every revolution, the engine when working at full power can be run steadier than can those having an impulse only every two or three revolutions. This feature of igniting the combustible mixture two or three times oftener than in the ordinary gas engine, while only using the same quantity of gas, enables the motor to be put into less space, and the weight per horse-power is considerably reduced, the latter consideration being of some importance where the engine has to be placed on an upper floor. When the work is of an intermittent nature the governor automatically regulates the exact quantity of gas needed to perform the actual work done. We shall be glad to have particulars of its performance at the approaching exhibition.

THE "Borough Engineer" as if his duties were not already enough to, at times, drive him very near the verge of distraction, will now have to add another to his innumerable accomplishments. Mr. Silcock, whose remarks on electric lighting we print on another page, has come to the conclusion that everyone of his *confreres* must eventually add electrical engineering to their professional duties. Perhaps it would be easier to turn those who have already acquired an extensive knowledge of the subject into borough engineers; but these matters will settle themselves in the ordinary course of events. We feel inclined to agree with the President of the Congress of the Association of Municipal and Sanitary Engineers and Surveyors, who remarked that it was questionable whether electric lighting should ever be added on to the work of the town official. One thing is quite certain, and that is that in the present stage of electric lighting his time would be so fully occupied with his new duties that many others would go to the wall. The lapse of time and further improvements might, however, bring with them less necessity for devoting the bulk of the day to solving problems in electrical distribution.

A WRITER in *Fair Play* attempts to teach his readers the dynamo principle. He says, "if we take a piece of wire in our hands and move it past the end of a magnet we shall find that in the act of so moving it we have set up a current of electricity in the wire." He furthermore states that instead of a short length of straight wire we can have a great length rolled into a coil. Now, half truths are not sufficient when one is engaged in trying to instruct the uninitiated; and it is absolutely fallacious to state that a current is generated in a short length of straight wire when moved in front of the magnet pole. One can see perfectly well what the writer is driving at, but he has not mastered his subject sufficiently well to instruct others.

WE are enabled to state that satisfactory progress is being made with the preliminary arrangements in connection with the Electrical Engineering and Mechanical Inventions Exhibition, which is to be held in Edinburgh next year, to commemorate the opening of the Forth Bridge. An influential general committee of over 200 members has already been formed. The Marquis of Lothian, Secretary of State for Scotland, has been approached with the view of obtaining his lordship's services as president. In Glasgow an important committee is in course of formation, and it is intended also to give other large cities an opportunity of contributing to the success of the exhibition. Support has been promised from America, and some of the exhibits in the Paris Exhibition are to be transferred to Edinburgh. Altogether, the prospects of the exhibition are most encouraging.

IN the description of Carl Hering's wire coupling, which we give on another page, the statement, on the authority of the *Electrical World*, is there published that joints as ordinarily made offer 50 per cent. of the total line resistance. So far as this country is concerned we scarcely need say that such joints as are here indicated would not be tolerated, and we can hardly think that our contemporary correctly represents American practice. Nevertheless the remark affords an opportunity of suggesting that very valuable information might be obtained, particularly by electric lighting companies, as to the real difference that jointing makes in the conductor resistance. Doubtless quite a number of methods are employed in connecting together copper leads, and if the resistances of several conductors of different diameters, but of the same length, which should be considerable, were taken, and the wires afterwards cut up into, say, a dozen separate lengths, and then jointed, it could readily be ascertained by a second test what difference had been made in the resistance, and the comparative value of various kinds of joints could also be determined. If such an enormous variation as that stated by our contemporary comes into the question it should be taken into consideration when selecting the size of lead to carry any given current, but we doubt whether the matter of jointing, as affecting the resistance of the conductor, is ever taken into account at all.

IT appears, judging from M. Bovet's lecture on the electric light at the Paris Exhibition, that the syndicate which was formed to carry out the necessary arrangements will have no cause to regret the financial results of its enterprise. There is money and to spare for carrying out any number of enterprises in this country, but the difficulty is to get adherents to any scheme which does not at the first blush look particularly rosy; perhaps the success of the French Syndicate may do something towards loosening the purse strings of some of our financiers who have hitherto held aloof from participating in any new venture.

It is evident that there is still need of a great improvement in incandescent lamps. Mr. Silcock, whose practical paper on p. 32, is well worth perusing, calculates that if consumers can be supplied with electrical energy at a cost equivalent to gas at 3s. 9d. per 1,000 cubic feet, it is necessary to allow another 9d. for breakages, which brings the cost up to gas at 4s. 6d. He reckons the average life of a lamp to be 1,000 hours; to prolong this to twice or three times that period means considerable reduction in the cost of electric lighting.

OUR esteemed contemporary the *Electrician* seems to have discovered a bogey by which timid manufacturers may be frightened. In the Edison patent for laminated armatures they see a possible means of Messrs. Mather and Platt, the present owners, claiming royalties from other makers, but up to the time of going to press we do not find that any intimation has been made to manufacturers of such an intention on the part of the eminent Salford firm. We have far too high an opinion of Messrs. Mather and Platt to imagine for one moment that they contemplate the policy at which our contemporary hints.

THE CONDITION OF ELECTRIC LIGHTING IN BUDA-PEST.

By OUR CORRESPONDENT.

THE travelled stranger, during a stay in the capital of Hungary, is involuntarily struck with the fact that in a city which presents otherwise so many attractions, and which has developed itself with such astonishing rapidity, the electric light is mainly conspicuous by its absence. Whilst in our days one city after another fits up electric works, or permits them to be established as private undertakings, whilst in the neighbouring capital, Vienna, at this moment three large electric central stations are in course of erection, in Buda-Pest not even the preparatory steps for establishing electrical works have been taken. Save in large industrial concerns, which can generate the electric light cheaply for themselves, the number of places lighted electrically is vanishingly small. Of all the theatres, the National Theatre is the only one which has electric lights at its disposal. Even the Royal Hungarian Court Opera House (a splendid monument of architectural skill) is lighted with gas.

This phenomenon is the more remarkable, as Buda-Pest is the seat of a firm which has done great things in electrotechnics, and which has become especially distinguished in lighting cities—a sphere in which it has rapidly obtained a high reputation in all parts of the world. In view of the enterprise, and the well-known patriotic character of this firm, the question is justified why the installation of electrical work is not carried out here so as to place the electrical light within the reach of persons who are not in a position to fit up the necessary machinery in their own houses. The only cause for this generally-lamented state of things is the (probably unique) stipulation of the covenant with the local gas company, which concedes to the latter body the exclusive right to use the territories of the public squares, streets and roads for laying down conductors for any kind of lighting whatever.

Since the position of things created by this clause proved itself a hindrance to the development of the city, and very oppressive for a portion of the inhabitants, steps were taken on the inducement of memorials addressed to the authorities to ascertain from the gas company how the public demand could be satisfied. But the company seems to regard it as their proper and most advantageous policy to insist firmly upon their bond, and to remain motionless, in opposition to the urgent wish of the authorities and the citizens. As speedy decision and energetic action are rarities in the Town Hall, it may happen that small provincial towns such as Agram, Great Kanizsa, and Keckemet will be in the enjoyment of the electric light sooner than Buda-Pest.

This opinion will be entertained by everyone who reads attentively the communication which the board of the Gas Company about two months ago addressed to the Mayor in his capacity as President of the Metropolitan Lighting Commission. This commission on March 31st addressed to the Gas Company the enquiry whether, and on what conditions, the said company would agree to supply certain lines of streets with the electric light? Not until the complete lapse of the term open for a reply did the Gas Company vouchsafe a reply. It might naturally have been expected that if the company were really disposed to meet the wishes of the authorities and the people and not to protract the matter, they would have come forward with definite proposals and made known on what conditions they would be prepared to undertake the introduction of the electric light. Nothing of the sort! In a very haughty style the worshipful Gas Company informed the Mayor that in his official communication there occurred a clerical error (!). With equal condescension they explained to the Mayor (who in their opinion is not duly aware of the extent of their rights) how they interpret the latter. They informed him that it was the place of the city to take the initiative in any negotiations and to lay before the company their conditions. Thereupon the company would decide whether they would introduce the electric light on such terms, such being their right in virtue of the agreement. The company further explained that they were certainly not indisposed in principle to introduce the electric light, but that they must first come to an understanding with the municipality as to the conditions. What the nature of these conditions will be the Gas Company indicate. In the first place they require an exclusive concession for a term of years, that is, a new monopoly before the present oppressive one has expired.

The Gas Company shows the disposition to raise a series of questions which require long and complex negotiations. They calculate very correctly that these negotiations in our slow business routine cannot be quickly concluded. Until then the *status quo* will be maintained which will best serve their ends. This situation in which the City of Buda-Pest is now placed with respect to the gas company is surpassed in strangeness —we might say in absurdity—only by that of the town of Szegedin. This municipality not merely conceded to the gas company a long and valuable monopoly, but it further bound itself during the time of the agreement to use exclusively gas lighting in all buildings which are municipal property. Thus arises the anomaly, probably unique in its kind, that Szegedin in its public edifices—which, by the way, are for the most part splendid structures—must *nolens volens* burn gas, and may not procure for itself the advantages of electric lighting, even at a heavy outlay. Unfortunately for the splendid theatre, which would be an ornament to any capital city, it is also the property of the town; the municipalty has been repeatedly desirous of superseding the existing gas illumination by the electric light, especially when a few years after its completion the gas-lighted theatre was burnt down and had to be rebuilt; as this improvement, however, does not meet the views of the gas company, it absolutely refuses its consent, in reliance upon its agreement, and the theatre-loving public of Szegedin must still, therefore, "*ad majorem gasis gloriam*," perspire in the heat of gas lights and dread the possible recurrence of a conflagration. The town of Szegedin, as it appears from the above, has completely delivered itself over to the mercies of their gas works.

But in Buda-Pest the position is not so deplorable, since their gas agreement gives the city the right even against the will of the company to erect electric works, or cause such to be erected, if a system is employed which is secured by patents which the gas company cannot use. Curiously enough, however, the municipality of Buda-Pest seems only to know those points of their agreement to which the gas company has thought proper to call their attention. In the mean time such small provincial towns as Keckemit, Szatmar, Kronstadt, &c., are busy with projects for the construction of electric works. When the capital, Buda-Pest, has been outstripped by the provinces, it will perhaps summon up courage to read its gas agreement.

A BOROUGH ENGINEER ON ELECTRIC LIGHTING.

AT the Annual Congress of the Association of Municipal and Sanitary Engineers and Surveyors, which was held at Portsmouth on the 4th, 5th and 6th insts., Mr. E. J. SILCOCK, Assoc. M. Inst. C.E., Assoc. Inst. Elec. Eng., and Borough Engineer of King's Lynn, read a paper entitled "Notes on Electric Lighting." At the outset he said, that as electric lighting might now be said to have passed the experimental stage and reached the practical, and recent legislation, by extending the time before local authorities could compulsorily buy up the undertakings of private companies, had removed the only bar which for the last year or two had prevented capitalists from entering the field, the indifference which had hitherto prevailed on the subject with reference to the question ought not to be allowed to continue. They might expect in the very near future that central lighting stations would be established in most of our large provincial towns as they were now being established in the Metropolis and other places. Then clients were in most cases interested either as a body or as private individuals in gas works, and therefore it was probable that in many towns corporations would not themselves run electric lighting stations; this, however, would not prevent private companies being started, as the Board of Trade had now power to grant provisional orders to companies where corporations refuse or neglect to undertake the work. These private companies would come into their midst, break up their streets, interfere with extensions of their sewers, drains, gas pipes, and water mains, and generally ride roughshod over public and private right unless they were duly restricted when obtaining their Parliamentary powers. To whom, then, must their corporations look to advise them in obtaining these proper restrictions? There was no official connected with their municipal governments, except the borough engineer, who was at all competent to cope with this question; and undoubtedly it was the duty of every one of them to make themselves masters of the subject, so that when the time comes they would be able to advise their respective clients in this matter as they would do in any other engineering undertaking. Their duties extended further than this: when once a company was started in any town, one of the first places that the undertakers would seek to light would be their municipal buildings and streets, and then the borough engineer would be called upon to design the consumer's part of the work of installation, and in some cases where the Corporations took up the central station lighting themselves, they might be called upon to design the works of supply. There was also another view of the question: the work of the profession was generally under-estimated. No doubt this arose from what was ignorantly deemed the ordinary nature of their work, and its want of special character. By adding to the duties of the borough engineer that of electric lighting, a natural addition to his work would be made which would be deemed extraordinary, and so to some extent act as a set off against the want of appreciation in other respects. The alternative to the borough engineer doing his work would be that electrical engineers would be called in, and a new department would be formed in their towns, the work of which should naturally and would ultimately come into the hands of borough engineers; the latter event, however, not taking place until the work had become ordinary, and all benefit from the introduction had passed away. This view of the question, together with the rapid strides which the science of electric lighting had made since the last paper was read, induced him (Mr. Silcock) to bring the subject again before the association. After some remarks on the broad lines on which an installation is designed and the sizes of the engines and dynamos to produce the required power, he said that high speed engines coupled direct to the dynamo offered great advantages. They took up little room, and avoided all losses of transmission by belting or other methods of gearing. Steam engines were always to be preferred to any other form of motor in large installations, unless water power was available, but good work could be done by gas engines. The important point about the engine, of whatever type it might be, was that it should be well governed. Electric lighting could never be successfully accomplished unless the engine ran at a perfectly uniform rate at all loads. Having described the several classes of dynamos, Mr. Silcock interpolated a few words in praise of electrical engineers. It was to their credit, he said, that machines could be purchased giving an efficiency of 93 and 94 per cent., that was to say, for every 100 horse-power transmitted to the dynamo from the engine, 93 or 94 were returned in the shape of electrical energy for utilisation outside the machine. It was only a few years since dynamos were first made commercially, and yet they had now in their hands machines which were more perfect than any other type of machine. An instance of the rapid improvement in electrical machinery was given. He (Mr. Silcock) was connected with an installation put down in 1883, the dynamos of which were considered good at that time. They gave an efficiency of about 66 per cent., and to-day they were working side by side with dynamos which were delivered under contract to give an efficiency of 94 per cent. Mr. Silcock offered suggestions as to the wiring of an installation, which, he said, was somewhat analogous to designing a system of water mains for a town supply. In testing for insulation, two facts should be borne in mind: 1st, that a high initial insulation was no criterion of the durability of the material; and 2nd, that the insulation of the cables, and of the installation as a whole, were two very different quantities. It was therefore very advisable to specify that the contractor shall stand by the insulation for as long as was possible. Eminent electricians said five years were not too long. It was necessary, therefore, to test the cables before fixing, and Prof. Jamieson, of Glasgow, adopted the following rule, viz., one megohm per lamp for every volt, the coils being submerged in water not less than six hours, immediately before and during the tests; if the coils did not considerably exceed that minimum, they were subjected, whilst in water, to an electromotive force 50 per cent. greater than the proposed working electromotive force, and again tested. A revised set of rules for the fitting up of installations to prevent fire risks had been recently drawn up by the Institution [illegible]ctrical Engineers, and they should be inco[illegible]n all specifications for contract work; but as several of the fire insurance offices had rules of their own, it was necessary, if the building to be lighted were insured in one of these offices, to specify for their rules to be carried out in addition to those of the Institution of Electrical Engineers. Dealing with the question of lamps, Mr. Silcock said that incandescent lamps had been tried for street and out-door lighting and proved an utter failure; on the other hand, for such positions the arc lamp was more suitable. For railway stations, covered markets, and similar places, the lamps might be suspended from the roofs in convenient places, but always so high up that the lamps would not fall within the field of vision. In large open spaces the lamps might be suspended from masts. In street lighting a 2,000 candle-power arc lamp would light up a radius of 80 yards when placed over the centre of the street, but only two-thirds of that distance when placed against the buildings. The necessity for arc lamps placed in the centre of the street being high enough to allow of the passing of a fire-escape was not of vital moment, as at most it would be only 25 feet, whereas the light was sufficient for 80 yards. The central lighting of towns might be effected in one of three ways, which might be briefly described as follows: 1. Direct supply—This system is adopted by the St. James and Pall Mall Company and the Bradford Corporation. 2. Transformer system—This system is adopted by the London Company, the Metropolitan Company, the House-to-House Company, the Eastbourne Company, and others. 3. The accumulator system—This system is used by the Chelsea Company, and the Kensington and Knightsbridge Companies, and will be used by the Notting Hill and Westminster Companies. The relative merits of these three systems are not finally settled, but it may be said that the direct supply system is practically limited to small towns, or to the more densely populated parts of large towns. For the supply of large towns from one station, or for sparsely populated districts, either the transformer or accumulator systems must be adopted. After referring to the arguments for and against these latter systems, as concisely summed up by Major Cardew, he said that two defects were mentioned by the Major in the transformer system, viz.: that alternating dynamos could not be run in parallel, and that no successful alternating motor is likely to be brought out. He (Mr. Silcock) thought that these two difficulties were overcome, and that if Major Cardew were writing his remarks to-day he would not name them. All distributing cables should be laid underground. Many forms of conduit had been devised for the purpose of protecting the cables, but probably nothing will be ultimately used but ordinary cast-iron pipes. In the Bradford installation the cables were simply laid in the ground and covered with boards. Where cables were laid in conduits they should be insulated with vulcanised rubber, as condensation was certain to take place inside the conduit, and if the wires were not insulated leakage would take place, but lead covered cables were unnecessary where conduits were provided; they were adopted in some installations without conduits; in such cases they should be sheathed in iron to prevent mechanical injury. It should be taken as a principle that meters should be employed for measuring the current used by each house and not an annual charge per lamp. The cost of installations of electric light varied very much, but it might be useful to the members to give them some actual figures of cost. An installation of about 2,000 16-candle-power incandescent lamps, supplied direct from dynamos driven by steam engines designed and erected by Mr. T. Hewson, M.I.C.E., borough engineer of Leeds, for the Leeds Corporation, cost in round numbers 50s. per lamp, including boilers, iron chimney, engines, dynamos, cables, lamps, and fixing. Central stations vary even more than home installations, but an installation of 37,500 lamps, 10 candle-power, for Leeds, including site, buildings, chimney, engines, dynamos, cables, transformers, and meters, would cost about 30s. per lamp; the plant to be capable of supplying two-thirds of the total number of lamps at one time with the necessary surplus power. This would leave the consumers to supply their own wiring, lamps, and fittings, as in the case of gas, and this would probably cost £1 per lamp, unless very expensive fittings were used. The cost of working at Leeds, according to Mr. Hewson, came out at ¼d. per 16 candle-power lamp per hour, and probably a 10 candle-power lamp could be supplied from a central station at the rate of ⅛d. per hour, without profit, but including interest and depreciation. In the metropolitan area it was proposed to charge on a sliding scale at a maximum price of 8d. per Board of Trade unit (1,000 watt hours). This would probably mean that the consumer of large quantities would be charged about 6d. per unit, which was equivalent to gas at 3s. 9d. per 1,000 cubic feet. To this must be added the renewals of lamps, which, taking 1,000 hours as the average life, made the cost of electric lighting equivalent to gas at 4s. 6d. per 1,000 cubic feet to the consumer. Three years since electricity cost the consumer over an equivalent of gas at 7s. per 1,000 cubic feet. The reduction in the price of gas from its introduction was not by any means so rapid as that of electric lighting had thus been, and apart from the certainty of further development in the art of electric lighting, the lapse of patents alone (of which so many now fetter the work) would, in a few years, reduce the price far lower than it was to-day. The cost of running 2,000 candle-power arc lamps might, perhaps, be put down at 2½d. per lamp per hour, to cover all charges, but not make a profit. Leaving the scientific aspects of the question, Mr. Silcock commended to the association the following conclusions:—That by reason of a corporation being able to borrow money at a cheaper rate than would be deemed a satisfactory profit to a company, and that it need not make a profit, it can supply electric light to its ratepayers far cheaper than a paying company would. That any future discovery in electric lighting which would produce it more cheaply, would, for long periods, benefit the shareholders of a company only, revisions in the price being at intervals of perhaps ten years. That the principle of keeping entire possession of the streets is one which the experience of all towns in regard to tramways, gas, and water companies has taught them should never be yielded. That although a local authority may agree with a company to light a town for a shorter time than the 42 years named in the Act of Parliament, a company would only agree to this on receiving advantages equivalent to them to the reduction in time.

A short discussion followed the reading of the paper, during which Mr. **Crimp**, of Wimbledon, gave his experiences of the success of the 60 C.P. incandescent lamp for street lighting.

Mr. **Lemon**, of Southampton, said that he had been concerned in framing regulations for the conduct of a company in that town, and he was only surprised that the promoters of that undertaking had consented so to be tied up in all directions. He himself was not in favour of all borough engineers being electrical engineers; for he considered that they had enough to do already, and he did not think they were likely to be so successful as men who had made the subject an especial study.

The **President** expressed his belief that municipal engineers generally were waiting to see what was the outcome of the electrical question, because they had not the time to follow its daily workings. It would be a subject requiring considerable attention whether electric lighting should ever be put on the daily work of the town official.

The usual vote of thanks was accorded Mr. Silcock for his paper.

THE ELECTRIC LIGHT AT THE PARIS EXHIBITION: ITS WORKING AND ITS RESULTS.

In the Electrical Review for April 12th we gave some exhaustive details as to the lighting of the Paris Exhibition by electricity. We now place before our readers some of the results obtained by that lighting, merely premising that the main particulars are taken from a lecture delivered by M. Bovet, director of the International Syndicate of Electricians, before the Society of Civil Engineers.

M. Bovet commenced by setting forth the exact distribution of this light, which, as stated above, we have already given. He then entered into details. The table which he had shown, he said, indicated the total luminous intensity obtained by the whole of the lamps employed in the lighting of the Champ de Mars, admitting that each *foyer*, taken separately, gave a luminous intensity of

Regulator	for an arc of	8	ampères	100	carcels.
	„ „	25	„	350	„
	„ „	60	„	1,000	„
	for a Jablochkoff candle		...	40	„
	„ a Sun lamp	...	...	100	„

As to the incandescent lamps, they had been defined precisely by their luminous intensity. There was, it seemed to the lecturer, no interest to connect this total luminous intensity with the surface lighted. Such a calculation gave an indication without great value, even in the case of large continuous surfaces without partitions, for it was very clear that according to the division of the lamps one could with a similar total surface and a similar total intensity obtain at such and such a point very different results. Let the fortune of a country be divided by the number of its inhabitants, and a result would be arrived at which would evidently give no indication as the mode of division of the public fortune. It was nearly the same with the question which occupied them. It was therefore the distribution of this light which might be interesting. For certain parts of the Champ de Mars the light called for no particular observation; at others, on the contrary, it was necessary for them to stop. The lighting of the gardens is in this position: it permitted of the simultaneous employment of Jablochkoff candles and incandescent lamps—the first designed to assure the necessary light; the second, before everything, assisting in the decoration. In the first place, the number of candles might appear small; they, however, thought it sufficient, estimating that the lighting of a large park should be discreet, and limited to what was necessary to allow of free circulation. As to the small lamps distributed in large numbers among the shrubs and lawns, they produced in the verdure a veritable illumination. Their lines of fire assured the continuity of the luminous decoration from the cordons of gas at the Trocadéro to those of the great dome, while elsewhere they give a larger quantity of light precisely at the points where the public take up their positions. The large *foyers* are disposed in the planted parts of the parks; almost the entirety of the decoration by incandescent lamps is joined on the lawns in the middle of the garden. It is there that the fountains are, and there, consequently, that it was of interest to have the least luminous intensity, in order not to injure the effect which they should produce. All this lighting had been studied very closely by M. Alphand, and everyone knew the marvellous art which he had adduced in the parks and gardens.

Never before had the lighting of such a structure presented itself. This was evidently the most interesting part of the task confided to the syndicate, and its president, M. Fontaine, pursued the study of it with special care. The lighting of the great nave is double. It might be obtained by means of four large lustres, each bearing 12 lamps of 60 ampères, or, in all, 48 lamps of 60 ampères. The lustres are portioned out regularly over the length of the palace, the length of the great axis, and suspended at a height of 40 mètres above the floor. The carbons are enclosed in globes of clear glass. This first system of lamps could alone give a satisfactory light, corresponding to a total intensity of 48,000 burners. There is, however, a second series of apparatus, composed of 86 regulators of 25 ampères. These are attached to the trussed girders in the proportion of 5 per girder (for 18 girders that would be 90), but four of the girders each bear in the centre one of the large lustres. They are arranged by 5 in one direction and 18 in the other, and installed in such a way that, for the replacing of the carbons, they shall descend in the longitudinal ways, and not in the parts occupied by the exhibitors. They burn at a uniform height of 15 mètres from the ground, in white globes, slightly rough. This second series of apparatus will give a luminosity of a total intensity of 30,100 carcel burners. It is possible to light the two series together or separately. When the luminous fountains are working, the second series alone will light, for it is precisely the current employed by the four large lustres which is utilised in the illumination of the fountains. In any case, however, either of the two systems was alone sufficient to give enough light.

If, now, they closely examined the lighting obtained in the grand nave, they would see, said the lecturer, how right it was to protest against the habit of ascribing a given luminous intensity to a surface. The total surface was 44,000 sq. mètres. One of the two systems of lamps gave an intensity of 48,000 burners, the other 30,000, in all 78,000. That would be, it appeared, less than two burners per mètre. The admitted intensities were those which corresponded to the direction in which the lamps gave most light. It was known that the light of an arc had a very variable intensity in different directions. If one only wished to consider the averages, he might admit that the average spherical intensity for a regulator of 25 ampères was 200 carcels, and that it was 500 carcels for a regulator of 60 ampères. That gave, for the whole of the lamps, about 40,000 carcels, little more than a half-carcel per mètre. M. Brault, a former student of the Polytechnic School, and the Syndicate's engineer, had made some calculations on the light produced, at the level of the floor, by the system of lamps it was proposed to employ, taking into account at every point the light coming from all the lamps. The lecturer then said it was necessary to define the expression "carcel-mètre" he was about to use. He did not mean by it by any means the connection between a certain number of carcels and a certain number of square mètres. He meant, when he said that an element of surface received a light of *n* carcels-mètre, that it was lighted as it would be by a luminous *foyer* of an intensity of *n* carcels situated 1 mètre distant. That granted, the following were the results at which M. Brault had arrived, while admitting that the division of the light around an arc *foyer* was made according to the law indicated by M. Fontaine. He studied in succession:—1. The light produced at the floor level by the large lustres placed at a height of 40 mètres; this light varied between 2 and 12 carcels-mètre, and gave, on the floor, zones, distributed as was indicated by the curves shown. Then, 2. The light produced by the sytem of *foyers* of 25 ampères, which varied from 2 to 6 carcels-mètre, and gave, on the floor, the zones also shown. Finally, in placing the results obtained by the two systems of lamps in juxtaposition, he obtained, for the division of the light produced by all the *foyers* lighted at the same time, the zones which were pointed out to the audience, and a light varying from 4 to 15 carcels-mètre.

The lecturer then said he would not risk indicating any average whatever; it would be necessary to keep account of the extent of each zone, and the calculation had not been made; but it was very evident that the light produced was infinitely greater than the too summary calculations with which they were too frequently contented would make it appear. To serve as a point of comparison, he would remind them that the track at the Hippodrome received a light of about 3 carcels-mètre. As to the resolution of M. Fontaine to place all the regulators at a great height, and notably the lamps of 60 ampères, as high as possible, it was justifiable. These lamps, which were very powerful, were almost absolutely blinding, and it was necessary to place them as much as possible out of the normal field of vision. It was clear, nevertheless, that to lower them more would have been to have a more irregular division of the light. As to the diminution in the light, due to its remoteness, it was not so great as it appeared at first sight. If, in effect, the light produced by a single luminous *foyer* over an element of surface varied in inverse ratio to the square of the distance from the *foyer* from that element, it was easy to see that if, instead of a single *foyer*, there were an indefinite line of *foyers*, the variation became inversely proportional to the simple distance from the element of surface to that line. Whatever it was, it would soon be possible to judge *de visu* of what would be in reality the light obtained at the floor level, or, better still, at the average level of the showcases, tables, and instruments shown in the great gallery. The remainder of the lecture, we think, will be better given in M. de Bovet's own words, which we do as follows:—

"It remains for me to say how all this light will be produced, but the means of execution which the syndicate adopted result, in large part, in such an imperative manner, from its statutes and its organisation, that I am forced to say a few words in the first place. I will do so briefly. As soon as he was named Director-General of Works, M. G. Berger addressed himself to the Syndical Chamber of Electrical Industries to ask it to study with him the means allowing of the lighting, and consequently of opening a portion of the Exhibition in the evening. The negotiations broached, they were carried on by two of our colleagues, MM. Hippolyte Fontaine and P. Lemonnier. There was on one side and the other good will and a desire to secure a success. The negotiations were long and laborious, dominated by a grave difficulty—want of money. Credits had been opened for all the other working expenses—water, gas, steam, &c.; but there were none for light, and it was difficult to find them. One naturally thought of a previous deduction on the entries, but the entries were given over by special privilege to the guarantee society, who would not allow them to be touched. A first projected contract had to be abandoned because it handed over to the syndicate for lighting a moiety of the receipts accruing from the evening visitors, though, without the syndicate and without light, there would be no evening visitors, and therefore no evening receipts. A means of surmounting this grave difficulty was found at length, and a second contract was drawn up, by which was given to the syndicated electricians, conditionally on the organisation of an exhibition of lighting, possession of the Exhibition from 6 to 11 and all the evening admission fees, instead of a part, provided they gave half to the State. If the receipts exceeded a certain sum the syndicate's part decreased, or rather that of the State increased. Materially, the result was the same.

"The situation resulting from the treaty and the statutes was, in short, very clear. It was a question of organising a collective exhibition of electric lighting: all electricians were admitted to participate therein. The syndicate supplied its members with motive power; it had, to meet that expense, the small sum resulting from the subscriptions, but from that time each member of the syndicate regained his autonomy. He operated with his own material, installed by him, at his expense, risk, and peril, working under the conditions which suited him best, the sole reservation being that he must conform, for the placing, nature, and intensity of his *foyers*, to a uniform plan drawn up by the managers of the syndicate and accepted by all. This plan was naturally decided upon in view of the better division and utilisation of the light. What it was desired to show was the part which it was possible for the electric light to play in the lighting and decoration of vast spaces, the one covered, the others open. There was, however, no anticipated budget, no assured remuneration other than a participation in the receipts which now are, very evidently and very happily, largely assured, but which, at the time when it was a question of forming the syndicate, seemed still to be very problematical. It was then easy to judge of it by the hesitation shown by the greater part of those who were asked to join the syndicate. Since that, the situation has changed. The issue of Exhibition bonds has had as a consequence the forced sale, for a fixed sum, of the syndicate's rights to a portion of the evening admission fees. This modification, however, was brought about at the last moment, hardly a month since, and then all the operations were too completely involved for it to be possible to alter them. The syndicate's work remained what it was at the beginning, the grouping of a series of distinct exhibitions, distributed so as to cover the whole surface of the Champ de Mars.

"It had evidently been regarded quite differently. Considered as a simple concessionaire of a public lighting enterprise, the syndicate would have been able to establish within the precincts of the Exhibition a general canalisation, on which would have branched all the dynamos of the one part, all the lamps of the other. It would then have required of its adherents that their dynamos should be constructed for working according to rules determined in advance (it is very clear that in this case it would have had at the same time to have assured them a fixed remuneration), and there would have been found exhibited a model of a great canalisation, installed in view of the distribution of an enormous quantity of electrical energy. Such a canalisation, regarded from the public service point of view, would perhaps have been preferable; it would have given to the whole a much greater suppleness, it would have permitted of making good more easily a possible defect, and it would have given every facility, among others, of lighting certain lamps, according to the needs, with a certain dynamo. More or less successful, this would have been the exhibition of the syndicate's engineers, and not that of the members of the syndicate. It would have been quite another thing than that which has been done, more interesting maybe in some respects, evidently less in others; better or worse, that is not what I have to discuss here, for it is very clear that the conditions themselves of our organisation such as they resulted necessarily from the contract and from the statutes, and from the absence of any funds capable of giving to our enterprise a character of public service, permitted no choice. And I wish very much to place this fact in view, were it only not to leave unanswered some criticisms which have come to my knowledge, evidently emanating from persons very much convinced of the excellence of the second system of which I have spoken, but who forget that it was a question of a work undertaken by associates, who were only exhibitors and not contractors, and who had accepted heavy risks on condition of each being able to show his apparatus and his system of distribution.

"The signature of the contract relative to evening lighting dates from February 15th, 1888. The subscription list remained open till September 1st, so that everybody in every country should have time to hear of it and claim his right to subscribe. The syndicate, therefore, could not be definitively constituted till September, its first general meeting being held on the 22nd. The project of division of the light was at that time prepared in its main lines. It began work at once, and it was time. The syndicate, once constituted, was managed by a council composed statutorily of MM. Hippolyte Fontaine (President), Faby, Lemonnier, and Rau. Interpreting its statutes very liberally, it still received, after its constitution, some unimportant late subscriptions, and to-day it numbers 27 adherents, who, by nationality, are distinguished as follows:—16 French, 5 Belgians, 3 English, 2 Swiss, and 1 Alsatian. As soon as the syndicate was definitively constituted, it set to work to create on the land which it had obtained a certain number of central stations for furnishing motive power to its members. Before making a great general canalisation, it was naturally necessary to try to divide them according to the necessities of the lighting of the different parts of the Exhibition. Besides, the importance of some of the subscriptions was such that it became easy to appropriate to certain companies an entire station, so that they could completely instal themselves according to their personal methods, which gave rise to some very interesting comparisons."

NOTES ON THE DYNAMOS AT THE PARIS EXHIBITION.

I.

IN our issue of March 29th we described generally the arrangements which had been made for the lighting of the Exhibition, and since that date the spectacle which our description promised has been realised in all its glory and magnificence. The electric lighting at the Paris Exhibition is one of the wonders of the century; it is a climax to the progress of twenty years; it surpasses in grandeur everything in the domain of lighting hitherto conceived. But we are not to deal in these notes with the lighting of the Exhibition, though from an artistic point of view it is well worth attention. Though sorely tempted, we must sacrifice our poetic proclivities, and confine ourselves strictly to practical work. So with note-book in hand we proceed to "do" the dynamos in the Palais des Machines, making here a note and there a sketch of anything which strikes us as noteworthy. It is not our intention to describe in all their details every machine we see. By no means. We are writing these notes for the benefit of our readers: for electricians who, from the descriptions we publish from week to week, know generally what dynamos are like and how they are constructed. What appears to us worth mentioning we shall therefore notice. What seems to us as of no importance we shall pass over.

With the exception of Crompton and Company, no large dynamo makers are exhibiting in Paris. The Anglo-American Brush Company, Mather and Platt, Paterson and Cooper, and Elwell-Parker are conspicuous by their absence. Nor can the Crompton installation be properly termed an exhibit. It is, or was when we visited it, a somewhat greasy collection of Crompton dynamos and Westinghouse engines, which, though undoubtedly doing good work, stood sorely in need of a few coats of paint.

But if Britain is scarcely represented there is no lack of dynamos from other localities; and substantial machines, for the most part, they seem, well finished and carefully thought out. We were not disappointed as regards the dynamos. So far as can be judged from outside observation, they appear to be in most instances designed by engineers and made to run. Their peculiarities will now occupy our attention.

Foremost amongst the exhibitors we must place the Société Gramme, who exhibit a historical collection of machines representing the progress of twenty years. Here, sketched in fig. 1, for instance, are the magnets of a four-pole dynamo designed and exhibited in 1869 by the illustrious inventor from whom the Société takes its name. In this machine the commutator segments were brought through the interior of the armature, and the current instead of being taken off by brushes resting on a cylindrical surface, was collected by four equi-distant metal contact pieces, P, which fitted on the edge of the ring formed by the ends of the segments, and were kept up to it by springs. In 1879 was designed the field magnet shown in fig. 2, which is really a single horseshoe magnet with a divided yoke.

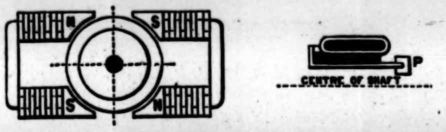

FIG. 1.

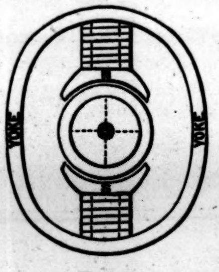

FIG. 2.

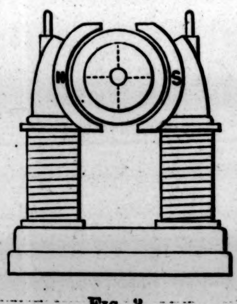

FIG. 3.

In 1883 the well-known machine of the single horseshoe type, with the armature inverted, fig. 3, made its appearance, while in 1884 the machine of 1879 again came to the front, but with the magnets greatly increased in mass, as in fig. 4, and the limbs lying horizontally instead of standing vertically. In 1885 Gramme designed the four-pole field magnet shown in fig. 5, the exterior frame being of octagonal form, and the magnets lying radially. These last three designs are reproduced by other exhibitors over and over again; and although it is quite true that a magnetic circuit, however shaped, is to the electrical engineer a magnetic circuit, and nothing more; still, it is to the originality of M. Gramme that these several designs which we have described are due, and it is to M. Gramme, therefore, that credit should be given.

A few yards from the exhibit of the Société Gramme is that of A. De Meritens et Cie. Here we have several of the well-known De Meritens magneto machines intended for use in lighthouses, also machines in which the construction, as regards the armature, is similar to the magnetos, though the steel magnets are replaced by electro-magnets for separate excitation. A machine is shown in this exhibit which, we believe, has not yet made its appearance in this country, that is the double armature machine of Marcel Deprez. Fig. 6 is a rough sketch of the machine in plan. A, A, are the two armatures, the windings of which are connected together at B, in order that the collection may be made by a pair of brushes from one single commutator, C. M, M, are four magnet limbs which rise and project from a spreading bedplate, D, D. It will be seen that the combination forms a single magnetic circuit as indicated by the dotted line, but with two armatures in the path of the induction instead of one, as usual. The object seems to be the more complete utilisation of the iron in the machine, symmetry of the field being obtained without sacrificing much weight in yokes or pole pieces. The design here shown does not manifest the object very clearly, however, and a much better example of the Deprez machine is to be seen at the exhibit of the Société pour la Transmission de la Force par l'Electricité. In this machine, fig. 7, the magnets lie parallel to the shaft, instead of perpendicular to it, as in the machine last described, the ends of the magnets being fitted with pole pieces, P, bored out

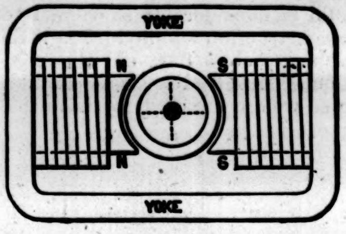

FIG. 4.

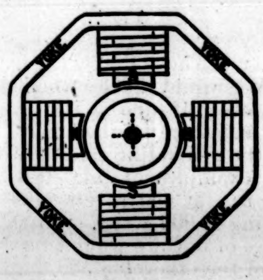

FIG. 5.

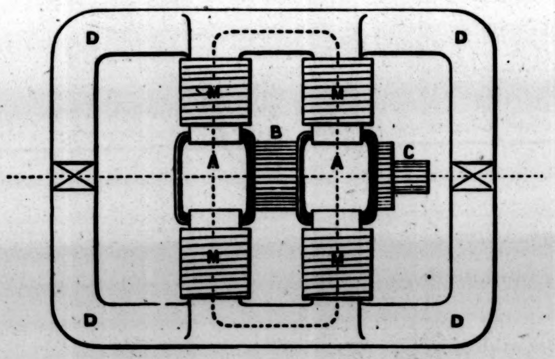

FIG. 6.

for the reception of the armatures. It will be observed that the second armature occupies the place which, if the machine had only a single armature, would be occupied by the magnet yoke, and though in the latter case the magnetising coils and therefore the magnetic circuit could be considerably shortened yet due to the particular construction adopted there is doubtless some saving in material. But, on the other hand, the combination is employed as two separate machines, and this being so we are inclined to think that it is a positive disadvantage to have the two armatures inseparably connected. We would much rather see two machines side by side, even if due to the yoke pieces being heavier, they together weighed more than the double machine. At the generating station of the Société there are two good examples of this class of machine, however. These run at 600 revolutions per minute, each armature giving 40,000 watts, or each machine 80,000. The armatures of one are wound for 70 ampères at 600 volts; those of the other for 500 ampères at 80 volts. Both machines are separately excited by accumulators charged from another dynamo.

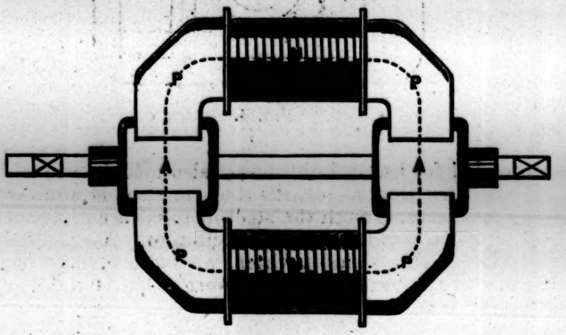

FIG. 7.

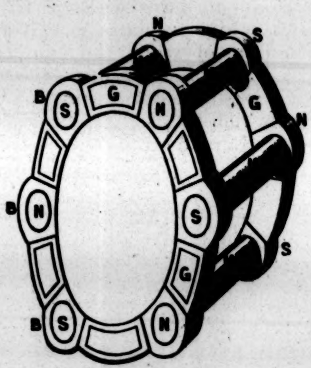

FIG. 8.*

Whilst we are expatiating on the Deprez type of dynamo let us mention a remarkable machine which we think must be a modification of this. As a precaution we say we think, because the machine was only being erected at the stand of M. Farcot, the engine builder, when we visited the Exhibition. What we saw was a number of men struggling with some heavy forgings, while mysterious gun-metal segment pieces lay strewed around them. The shapes of these pieces aroused our suspicions as to the ultimate character of the structure, so like the anatomist who pieces together odd bits of bones to build a quadruped of the past, we pieced together these bits of iron and brass to build up a dynamo of the future. In fig. 8* the magnet part of this machine is shown. It consists of six wrought iron bars, M, M, with a cast iron pole piece, B, on each end of each bar. Between the pole pieces are gun-metal segments, G, the whole when erected forming six wrought iron magnets parallel to each other and fitted at each end with pole pieces which are shaped for the reception of two armatures mounted on the same spindle. Of these armatures we could find no trace, but were we to visit the show later we should doubtless find them in their places with the magnetising coils mounted on the bars, M, making the poles alternately north and south around the armature as marked N and S in the figure. The machine, it will be seen, is nothing more than a six-pole double armature Deprez, but of its performances we may have something to say by-and-bye.

(*To be continued.*)

HERING VICE-GRIP WIRE COUPLING.*

NOT less important than good insulation is proper installation. One of the greatest facts in connection with this latter subject is the reduction of the line resistance to the lowest possible degree. Wire joints as ordinarily made offer 50 per cent. of the total line resistance. With this issue we have illustrated an extremely ingenious wire coupling devised by Mr. Carl Hering, in which the conditions which exist in a first-class wire joint are attained perfectly by a clamp which operates purely upon mechanical principles. The clamping is so extremely tight that the molecules of the materials are forced into intimate connection, and there is no resistance offered by the joint whatever. The ingenious methods by which these objects are attained are shown in the illustrations herewith :—Fig. 1 shows the coupling only. Fig. 2 shows the coupling with wires run through and ready to be fastened. Fig. 3 shows the coupling with wires properly fastened, in which the wire is tightly gripped, and the joint is perfect and neatly made for permanent use. Fig. 4 shows the coupling same as fig. 3, with the exception that the ends of the wire are twisted around and furnish additional fastening. This makes the grip of the wires extremely vice-like, and there is no danger of their ever coming

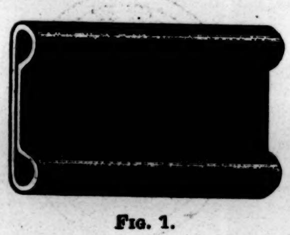

FIG. 1.

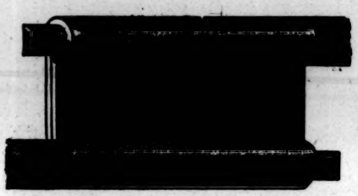

FIG. 2.

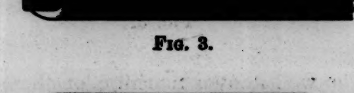

FIG. 3.

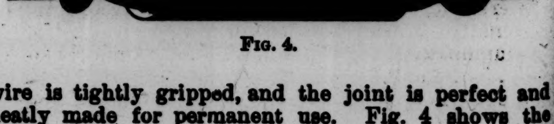

FIG. 4.

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* The sketch from which this figure was made was inadvertently left incomplete by the writer.

* *Electrical World.*

apart. The wires and joining parts are virtually welded together. The operation is so quick and simple that there is a great saving of time over the usual "twist joint." A very great saving of time is also made over the ordinary soldered joint, of which it is a practical equivalent in low resistance and strength.

They are made of stiff copper, and in every way suited to the purpose for which they are designed. No special tools are required in their manipulation. The ordinary pliers in the smaller wires, and the hammer in case of larger wires, are the only implements required. They are adapted alike for electric light wires, telephone and telegraph wires.

ELECTRICITY AT HENLEY.

MESSRS. M. IMMISCH & CO. are to be congratulated on having fairly and effectively introduced electric launches for pleasure purposes on the Thames. At Henley Regatta last week, in addition to the *Viscountess Bury*, capable of accommodating 60 to 70 passengers, the firm had five other electric boats, all of which were fully let for the week, being duly appreciated both by the hirers and by the onlookers, on account of their freedom from noise, smell, and smoke. The upper portion of the river is now studded with charging stations from Richmond up to Reading, the headquarters and principal station being on Platt's Eyot, at Hampton. On procuring a copy of the clever paper which devotes itself to chronicling the news of the river, the *Lock to Lock Times*, we were gratified to see that its best advertising page was occupied by two electrical firms, though the pleasure was somewhat discounted by the discovery that one of the said firms was only announcing the prices of its special manufacture of tin kettles. A third advertisement in the paper relates to the electric launch *Ray Mead*, which is let by its proprietor at £10 10s. per day, and is stated to have accommodation for 30 people. On another page for steam launches the charge is given at from £3 3s. to £7 7s. per day, the largest of which would probably not afford seats for so many as 30. Turning to Messrs. Immisch & Co.'s circular, we find that the hire per day of their electric launches, including men in charge, is from £5 5s. upwards, and the rates for recharging accumulators range from 11s. 6d. to 17s., according to the size of boat. We give these figures preliminary to contending that the cost of hiring an electric launch, compared with that of a steam launch, to accommodate the same number of people, is very little, if anything more, and that the cost of recharging is moderate enough to encourage a general adoption of electricity in preference to steam power.

We have not the means at hand of comparing in the same way the purchase prices of the two classes of launch, but we believe that the prime cost of the electric boat is somewhat more than that of a steam launch; but as a set-off against this, the owner of the electric boat can lay it up for any length of time without the anxiety and constant attention that must be required to keep an engine in good order. Although a 40 feet electric launch costs more than a 40 feet steam launch, it is not so clear that an electric boat to accommodate 40 people is any more costly than one with a steam engine for the same number, the fact being that with electric propulsion the proportion of space available for passengers is so much greater.

The copy of *The Lock to Lock Times* already referred to enables us to make another comparison. Under the head of "Delightful River Trips," the saloon steamer, *Oxford*, is announced to make weekly journeys between Oxford and Kingston, and the charge per head for a day's run is 10s. A small electric launch hired for the day at five guineas, would carry at least 10 persons, so that a party of ten or twelve would economise by having a private electric boat to themselves, instead of paying their fares by the public steamer. In the portion of the paper which is devoted to a description of the house-boats at Henley Regatta, it is recorded that the owner of the *Golden Grasshopper*, the most complete establishment of that kind on the course, had an electric launch alongside, which not only answered the purpose of a tender by day, but at night afforded a supply of electricity sufficient for lighting the tastefully decorated saloon of his house-boat.

We are glad to hear that Messrs. Immisch & Co. are receiving every encouragement to enlarge their field of operations, and that they have in course of construction a number of launches either being built to order or for addition to the fleet, which the firm intends keeping on hand for sale or hire. So large a proportion of the river-loving public are well able to afford the luxury of an electric launch that we fully expect to see the business develop into an extensive and fairly profitable one.

There is, however, one factor in the working of these electrically propelled boats which may eventually lead to some inconvenience. Already we learn that the inhabitants of Richmond are protesting against the charging station, with its smoke and noise, which are voted a nuisance; and it does seem a little unreasonable to abolish smoke on a small scale by substituting electricity for steam on pleasure craft, and then to concentrate it largely at given points on the river. Should the opposition prove very strong, there is no reason why the smoke should not be abated, or, indeed, done away with altogether.

ELECTRIC LIGHTING AND THE COUNTY COUNCIL.

IMPORTANT REPORT OF THE HIGHWAYS COMMITTEE.

LAST Tuesday, at the usual weekly meeting of the London County Council in the Guildhall Council Chamber, under the presidency of the Earl of Rosebery, the Chairman of the Highways Committee (Mr. Alderman A. H. Haggis) presented an important report dealing chiefly with the subject of electric lighting in the metropolis. The committee reported that their Chairman and Mr. Benn, one of the members of the committee, had had several interviews with the Board of Trade with a view to amendments being made in the model Provisional Order under the Electric Lighting Acts, 1882 and 1888, proposed to be adopted with respect to areas of supply in London; and that many of the amendments suggested by the committee had been adopted by the Board of Trade, and embodied in the Orders granted. The following letter has since been received from the Board of Trade:—

Board of Trade (Railway Department),
London, S.W., July 1st, 1889.

Sir,—I am desired by the Board of Trade to forward to you, for the information of the London County Council, copies of Provisional Orders which the Board of Trade have granted in the Metropolitan area under the Electric Lighting Acts, 1882 and 1888.

The County Council will observe that the provisions of the Orders vary in some particulars from the provisions contained in the model Order, of which a copy was forwarded to you on the 12th ultimo (R 8,604).

Modifications have been introduced in consequence of representations made to the Board of Trade since the preparation of the model Order.

In adopting them, the Board of Trade have had especial regard to the suggestions made by the Committee of the London County Council, with whom the Board of Trade have had the pleasure of discussing the subject, and clauses have been framed with the object, as far as possible, of giving effect to those suggestions.

It will be seen that a section has been introduced exempting from the powers of the undertakers interference with embankments, parks, or open spaces, not forming part of any street vested in the London County Council.

The committee were desirous that the public bridges vested in the Council should be included in this section; but no power is conferred by the order to interfere with any portion of a public bridge other than the roadway over it, and the Board of Trade are of opinion that the provisions of sections 13 and 15 will sufficiently prevent any works likely to be detrimental to a bridge, and that, in this respect, a roadway over a bridge should be dealt with in the same way as a street repairable by a local authority.

In forwarding these orders, I am again to thank the County Council and the committee for the aid which they have given in the matter.

I am, Sir, your obedient servant,
R. GIFFEN.

The Clerk to the London County Council,
Spring Gardens.

The Highways Committee further reported that the following orders were those which had been granted by the Board of Trade :—

House-to-House Electric Supply Company.
Kensington and Knightsbridge Electric Lighting Company.
London Electric Supply Corporation.
Metropolitan Electric Supply Co. (West London).
" " (Mid London).
" " (South London).
Notting Hill Electric Lighting Company.
St. Martin (Electricity Supply Corporation).
South Kensington (Chelsea Electricity Supply Co.).
Westminster (Westminster Electric Supply Corporation).

Mr. Haggis also reported that there were still several points in the orders with reference to which the committee considered that some amendments were necessary. They had therefore requested their chairman and Mr. Benn, with the assistance of the Council's officers and the Parliamentary agent, to confer further with the Board of Trade with the view to such amendments being made.

PROVISIONAL ORDERS FOR 1890.

The committee reported that the undermentioned notices of applications to be made in the year 1890 for Provisional Orders under the Electric Lighting Acts had been received :—

Name of Company.	Parishes and Districts referred to in Notices.
Chelsea Electricity Supply Co.	Kensington ; St. George, Hanover Square.
Electricity Supply Corporation	St. Giles, Strand, Paddington, St. Martin-in-the-Fields.
House-to-House Electric Supply Co.	Wandsworth, Fulham, Lambeth.
Laing, Wharton and Down Construction Syndicate, Limited	City of London.
London Electric Supply Co. ...	Area of which Council is local authority.
Metropolitan Electric Supply Co.	Certain streets and places to be hereafter specified.
Renshaw, King and Co. ...	St. Margaret and St. John, Westminster.
Westminster Electric Supply Corporation	St. Margaret and St. John, Westminster ; St. George, Hanover Square ; St. Marylebone, Paddington.
Company (about to be formed)	Hampstead, Paddington, St. Luke, Shoreditch, Clerkenwell, St. Marylebone, Kensington, Islington, Bethnal Green, Fulham, Hammersmith, Whitechapel, Hackney.

LEGAL.

United Telephone Company v. Liversedge & Co.—This action was heard on Saturday before MR. JUSTICE NORTH in the Chancery Division of the High Court of Justice.

MR. WICKLEM said the action came on upon motion for judgment in default of defence. The action was brought for an injunction to restrain the infringement of the Edison transmitter and the Bell receiver, and the claim asked that the infringing instruments might be delivered up to the plaintiffs. With the statement of claim particulars of breaches were delivered, and he asked for an order in the same terms in which the courts had previously made them, with costs up to judgment, the costs of the inquiry as to damages being reserved.

HIS LORDSHIP made the order as asked.

A similar order was made by MR. JUSTICE CHITTY in an action of the United Telephone Company *v.* Brierly, which was heard as a short cause, the defendant not appearing.

REVIEWS.

Practical Electric Bell Fitting. By F. C. ALLSOP. London : E. and F. N. Spon, 125, Strand.

This book is a reprint of a series of articles on the subject which recently appeared in the columns of the *English Mechanic*. Much additional matter has been incorporated, and a thorough revision has been effected. The history of electric bells for domestic purposes, it may not be generally known, dates back as far as the year 1850, when appliances of this kind were fitted up in the Senate House of Berne, Switzerland, by, we believe, Hipp, of Neufchatel. The first introduction of electric bells into England was by Messrs. Adams, of the Haymarket, London, about the year 1860, the patterns manufactured by Breguet, of Paris, being sold, and the Belgian globe Daniell battery being used ; the latter form of battery was not a great success, and the happy fate of the electric bell industry is probably almost entirely due to the invention of the Leclanché element. Although electric bells have not entirely taken the place of the old crank system, there is now scarcely a bellhanger, even in small towns, who will not contract to fit up either description, and very often with the result of continual failures ; to such tradesmen and others we would heartily recommend Mr. Allsop's work, as it is the most complete of its kind yet issued. The book is both well written and well illustrated. Almost every form of bell, indicator, &c., is described, the tools required for fitting are enumerated, and all necessary practical details are given ; the name of the book, in fact, thoroughly expresses its nature.

Thermo-Electricity. Theoretically and Practically Considered by the Aid of Thermo-Electricity. By ARTHUR RUST. London : E. and F. N. Spon, 125, Strand.

We are not particularly struck by this production. In fact, the writing in many cases makes one doubt whether the author knows what he is talking about. Many of the experiments given, however, are interesting, though it is difficult to judge of the value of the same ; thus the author makes his experiments with a galvanometer, the nature of which, as regards its resistance, he says nothing, hence many of the results he obtains *may* be due to low electromotive force *or* high resistance ; the author assumes they are due to the former, but inasmuch as the heating of the elements would increase their resistance, the current would be decreased from this cause if a low resistance galvanometer were being used. The author seems confident that what he calls his "Magnopile" will be a commercial success. Considering, however, the known exceedingly low efficiency of thermopiles, and seeing that the author does not appear to have made any experiments or devised any modification of the old lines, which mark any great advance, his expectations are, we fear, doomed to failure.

Telephone Poles in the New Forest.—At the last meeting of the Lyndhurst Highway Board, the clerk reported that he had been to Bristol and had seen the representative of the Telephone Company with reference to the erection of the wooden poles along the highway at Totton and Lyndhurst, complaint with regard to which had been made by Mr. Gulliver at the previous meeting. Mr. Roy said the roads had come under the County Council since leave had been given to the Telephone Company to erect their poles. In consequence of this, the County Surveyor had forbidden the company to erect any more poles until the sanction of the County Council had been obtained. Mr. Gulliver said that in the villages there was a desire that the wooden poles should be superseded by iron ones, the same as was done along the Shirley road. Mr. Roy said he would undertake to bring the wishes of the board under the notice of the County Council.

NOTES.

Electric Lighting in the West.—The Devon and Cornwall Electric Supply Company, Limited, which was registered in London a few days since with Mr. Luxon, of Plymouth, as secretary, *pro tem.*, is busily engaged in canvassing Plymouth with the view of ascertaining the measure of support likely to be received from that quarter. Should the result be considered satisfactory the company, which under its Parliamentary Bill has power to extend its operations throughout Devon and Cornwall, will make preparations for an early start, and circulars have been forwarded to the local authorities interested notifying their intention to do so.

Competitive Electric Lighting at Bournemouth.—At the last meeting of the Bournemouth Town Council it was stated that communications had been received from the Anglo-American Brush Electric Light Corporation, the Electric Construction and Maintenance Company, and the South of England House-to-House Electricity Company, each giving notice of their intention to apply for Provisional Orders with reference to the introduction of electric lighting into Bournemouth. The applications were referred to the Lighting Committee.

Busy in Electric Lighting.—Messrs. B. Verity & Sons, of Covent Garden, inform us that for some weeks past they have been exceedingly busy in electric lighting work. They have in hand at the present time the following:—Sherborne House, as well as the church on the estate, Northleach, Gloucestershire, for Captain L. Byng, Royal Horse Guards; Footscray Place, Kent, for Sir John Pender, K.C.M.G.; Riverhome, Hampton Court, and the beautiful Swiss Chalet on the River bank for Osborne O'Hagan, Esq.; the Commercial Bank of Scotland, City, and five mansions in London and Brighton for connection to central stations. The firm are also busy in the manufacturing departments, having secured the whole order for fittings for the Government House, Singapore, Straits Settlements. Messrs. B. Verity & Sons have also added to their catalogue upwards of 140 new designs in copper standards, brackets, &c.

Electric Lighting in the Navy.—Commander Batten, chief of the electric light department at the Admiralty, was busy during the last three or four days last week in testing the electric light apparatus which has been fitted on the gun wharf, and on board the new vessels *Warspite*, *Rodney* and *Australia*. The trials have proved in every way satisfactory.

Electric Lighting for Theatrical Effects.—We understand that the electrical effects produced in the new ballet, "Astrea," at the Alhambra, were carried out by Mr. C. S. Northcote for the firm of Messrs. B. Verity and Sons, of Covent Garden. There are over 200 5-candle-power lamps used, and half a mile of flexible cord; every set of 10 lamps is on a separate circuit, which is protected by a double pole cut-out on the batten. No lamp holders are used, the lamps being fixed by a special arrangement which has not been employed before. The effect produced has been announced by the Press to be very charming.

Removal.—Messrs. J. E. Spagnoletti and Crookes have removed from Adelaide Works, Uxbridge Road, to Goldhawk Works, No. 39B, Goldhawk Road, London, W.

Pension.—A Civil List pension of £200 has been granted to Mrs. Helen Patey, in consideration of the services rendered by her late husband, Mr. C. H. B. Patey, in the improvement of the telegraph service of this country.

The German Telephones.—The enormous stride made in the development in Germany of the telephone is illustrated by the following table:—

Year.	Number of Exchanges.	Number of subscribers.	Length of wire kilometres.
1882	11	1,884	3,770
1889	176	33,460	48,829

Interruptions and Repairs to Land Lines and Submarine Cables:—

Land Lines.	Interrupted.			Repaired.	
Siberian—At Blangowetschensk	May	5th	...	May	6th
Moulmein-Bangkok	„	8th	...	„	11th
„ „	„	14th	...		
Indo-European	„	28th	...		
Moulmein-Bangkok	June	17th	...	June	18th
Saigon-Bangkok	July	4th	...	July	8th
Submarine Cables.					
Rio Grande do Sur-Monte Video	April	25th	...	May	11th
Suakin-Djedda	May	10th	...	„	22nd
Saigon-Bangkok	„	14th	...	„	21st
Santa Elena-Payta	„	15th	...	...	
Lagos-Brass	...		...	May	15th
Para-Maranham	May	22nd	...	June	4th
Trinidad-Demerara	„	24th	...	„	6th
Ceara-Maranham	„	28th	...	„	1st
San Juan del Sur-Panama	June	4th	...	„	5th
Rio Grande do Sur-Monte Video	„	12th	...	„	27th
Assab-Massowah	„	13th	...	„	19th
Saigon-Bangkok	„	24th	...	July	1st
Mossamedes-Cape Town	July	2nd	...	...	

Communication with the Cape Interrupted.—The *Bureau International*, of Berne, announces that on the 2nd July the cable which connects Mossamedes, Port Nolloth, and Cape Town, was interrupted. Our readers will remember that this portion of the West African cables was laid by the Telegraph Construction and Maintenance Company's ship the *Scotia* in April and May. We should not be surprised to learn that the T-piece which is run into Port Nolloth has broken down, for it is rumoured that considerable difficulty was experienced in making the joint. We recollect that the *Scotia* was delayed off Port Nolloth for a considerable time. It is possible that the fault may prove to be in one of the land lines connecting the cable huts with the stations; but whatever may be the cause, the communication is interrupted, and it is to be very much regretted that a breakdown should have occurred upon a cable so very recently laid, and opened to the public but a short time since. For various reasons, considerable attention has been called to this new telegraph route to the Cape, and a mishap to the system, under the circumstances, is all the more to be deplored, since the effect must be to shake public confidence in the work of contractors who have borne so high a reputation as that possessed by the Telegraph Construction and Maintenance Company.

Electrically Treated Sewage.—Mr. Webster, the inventor of the latest treatment of sewage by electricity, has been visiting Maidstone with a view to the formulation of a scheme for the purification of the river Medway, which is now very much polluted by sewage.

Another Richmond in the Field.—The *Gas and Water Review* will henceforth be known as the *Gas and Water Review and Journal of Electric Lighting.* It has always held that the owners of gas undertakings who are suppliers of light should take up the supply of electricity; and, for the purpose, primarily of giving information upon the subject, the proprietors have determined to uphold electricity as a lighting agent. It is claimed that it is the first and only paper in the world which treats upon gas and electric light as combined interests. Is it a sign of the times, or has the *Gas and Water Review* met with such little support amongst its own *clientèle* that its proprietors think it may be more successful with the electrical fraternity? If the latter is the case it would be easy to disabuse their minds, judging from the electrical items in the copy sent to us for notice. Still we hail with satisfaction any addition to our ranks which can further, in however small a degree, the interests of the best illuminant.

Reducing the Coal Bill.—An invention that claims to effect a saving of 50 per cent. in the cost of fuel should possess the greatest possible interest for all electrical engineers, opening up, as it does, a prospect of the possibility of supplying electric light and power at a price much less prohibitive than that rendered necessary under present circumstances. The Hopcraft furnace has been sufficiently long in use to have proved by actual results that it is a genuine and practical means for effecting several most important ends. The most prominent of these is the material economy in the cost of fuel; but in addition to this, less manual labour is required, a largely increased duty is obtained from the boiler, and the prevention of smoke is perfect. At the works of Sir Joseph Causton and Sons, Hopcraft furnaces have been in operation for over a year, giving the greatest satisfaction, and showing a saving of 50 per cent. in the coal bill; and the result of some tests by the National Smoke Abatement Institution was that this furnace evaporated as much water per hour with Welsh dust as an ordinary furnace did with hard steam coal, the saving in cost in this case also being 50 per cent. The interesting report of these tests by Mr. D. K. Clark, will be sent by the Hopcraft Furnace Company to anyone interested in the subject.

"Money" and the Electric Companies.—*Money* says: "House-to-house electrical supply companies and other similar concerns with different titles are springing up with mushroom rapidity all over the country. In a number of cases the capital is monotonously alike, and at first blush they all look a very fine thing for—the directors. It would need a fairly lengthy article to criticise their merits or demerits, so we content ourselves at present by strongly advising investors to be on the alert, and as the electricity tap has been turned on, to be careful that they themselves are not too readily tapped." While agreeing with our financial contemporary that investors should be wary—in other things as well as in electric lighting schemes—we hope that the time is now at hand when real honest work can be depended upon to bring returns into the pockets of shareholders and to also reward the promoter.

That very important difference—overlooked last week by our contemporary the *Electrical Engineer*—between the companies forming now and those which blossomed so rapidly a few years ago, to die just as quickly, should be borne in mind. At this juncture capital is required not for construction companies or to pay for questionable patents, but for real enterprise yielding profitable returns on the outlay.

Transference of Business.—We learn that the electric business of the firm of Clarke, Chapman, Parsons & Co. has been transferred by mutual consent to the Hon. C. A. Parsons, the well known inventor of the turbo-electric generator, who will now carry on the whole of their business in connection with electric lighting under the name of Parsons & Co., retaining the whole staff of the department. In addition to the turbo-generator the manufactures of this firm include slow speed dynamos, arc lamps, projectors for the passage through the Suez Canal, for harbour entering and for war ships, and all other requisites for electric installations on land and on board ship.

King, Brown & Co. v. Anglo-American Brush Light Corporation.—The Anglo-American Brush Light Corporation have lodged with the First Division of the Court of Session, Edinburgh, a reclaiming note or appeal against Lord Trayner's decision finding invalid their letters patent granted in October, 1878, for improvements in electrical appliances. As the Court rises for the summer vacation on the 20th inst., the reclaiming note cannot be heard until the reassembling of the Court in October. It is not likely that judgment will be given before the end of the year, and thereafter, in all probability, an appeal will be taken by the losing side to the House of Lords.

The Shah and the Electrical Omnibus.—Mr. Radcliffe Ward and Mr. F. B. Behr, director of Ward's Electrical Car Company, exhibited their electrical omnibus to the Shah in the grounds of Buckingham Palace. Mr. Ward fully explained the features of his system of electrical traction as applied both to tramways, railways, and ordinary roads. The Shah seemed both pleased and astonished.

Parliamentary Bills for Electric Lighting.—Mr. Charles Harrison (as the chairman of the Parliamentary Committee) reported as follows:—"Four Bills have been introduced by the Board of Trade into Parliament for the purpose of confirming the Provisional Orders issued with reference to electric lighting in the metropolis. The Highways Committee has been in constant communication with the Board of Trade as to the frame of a model order, and many concessions have been made to meet the views of that Committee. Further amendments may, perhaps, be secured, but in order to reserve the position of the Council unimpaired a short petition should be presented against each Bill, and this should be done on or before Tuesday next. Your Committee have instructed the solicitor to prepare petitions, and they recommend: 'That the seal be affixed to the petitions, and that the solicitor be authorised to instruct one counsel to appear upon the first Provisional Order which may come into Committee.'" This proposal the Council agreed to.

The Electric Lighting Bills in Parliament.—On Wednesday, on the motion for the second reading of the Electric Lighting Provisional Order Bill, Sir M. Hicks-Beach, in reply to Sir G. Campbell, said the special report of the Board of Trade on this Bill had not been circulated owing to the delay of the printers. The Bill, and other similar Bills, were read a second time. A number of petitions in opposition to several London electric lighting provisional orders have been deposited in the House of Commons, among them being one on behalf of the Duke of Bedford and the Strand District Board against the Mid-London order; the Wandsworth District Board of Works petition against the South London order; the vestries of St. John the Evangelist and St. Margaret, Westminster, against the Kensington and Knightsbridge order, all the petitioners pray to be heard in committee; four by the London County Council against various orders, and ten on behalf of the Gas Light and Coke Company against the Westminster, the Knightsbridge, the Notting Hill, the South Kensington, the Mid-London, the South London, the West London, &c., schemes.

Ss. "Silvertown."—We learn that this cable ship, the property of the Silvertown Company, arrived in the Victoria Docks early on Sunday morning, the 7th inst. We are glad to hear that the health of all on board was exceptionally good throughout the voyage, with the exception of two or three slight cases of fever. This immunity from sickness is a matter of congratulation, seeing that a considerable portion of the work lay in the Bight of Benin and on the Gold Coast, localities famous, or rather infamous, even on the African littoral, for their unhealthiness.

Murray's Penny Pocket Guide to London.—The publisher has sent us a copy of this excellent little guide, which we think would be found useful by every one who is either a resident in London or a visitor. It contains a number of good illustrations from photographs, and an excellent map, divided in a most ingenious way for handy reference.

Revival of an Old Idea.—It is said that an invention which promises to revolutionise the method of discharging firearms has been lately under the consideration of the War Office. It consists in firing the cartridge by electricity, and experiments in connection with the new rifle are in progress.

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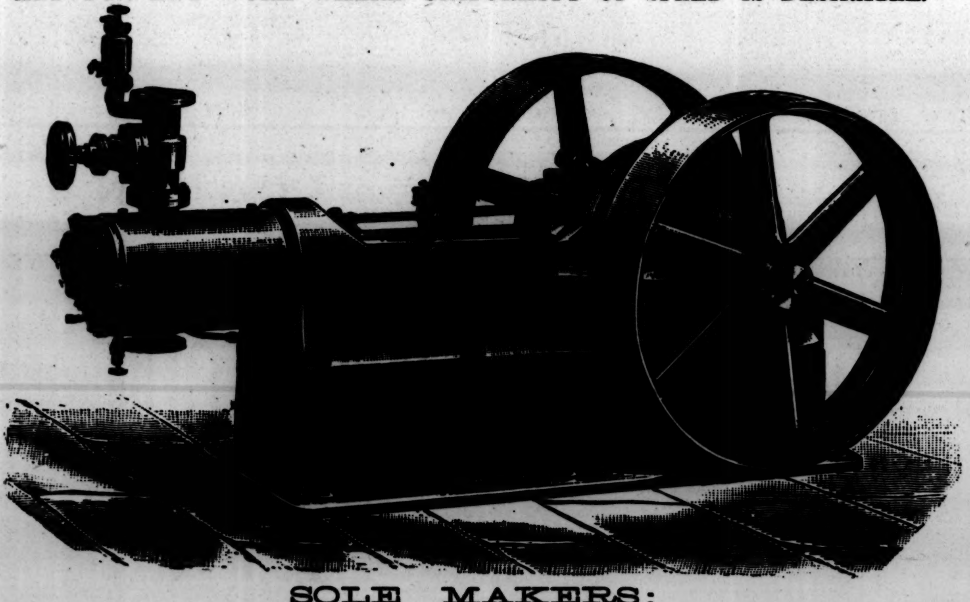

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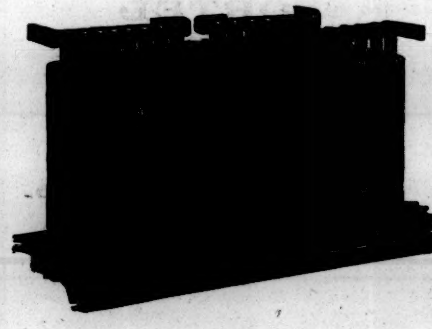

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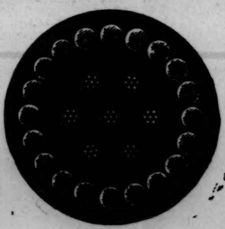

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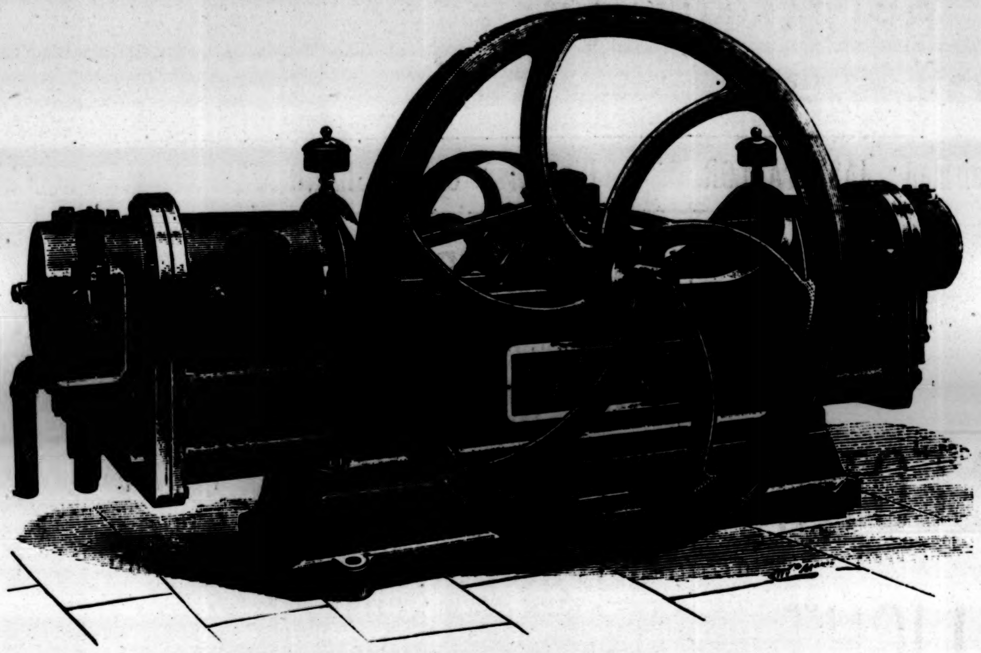

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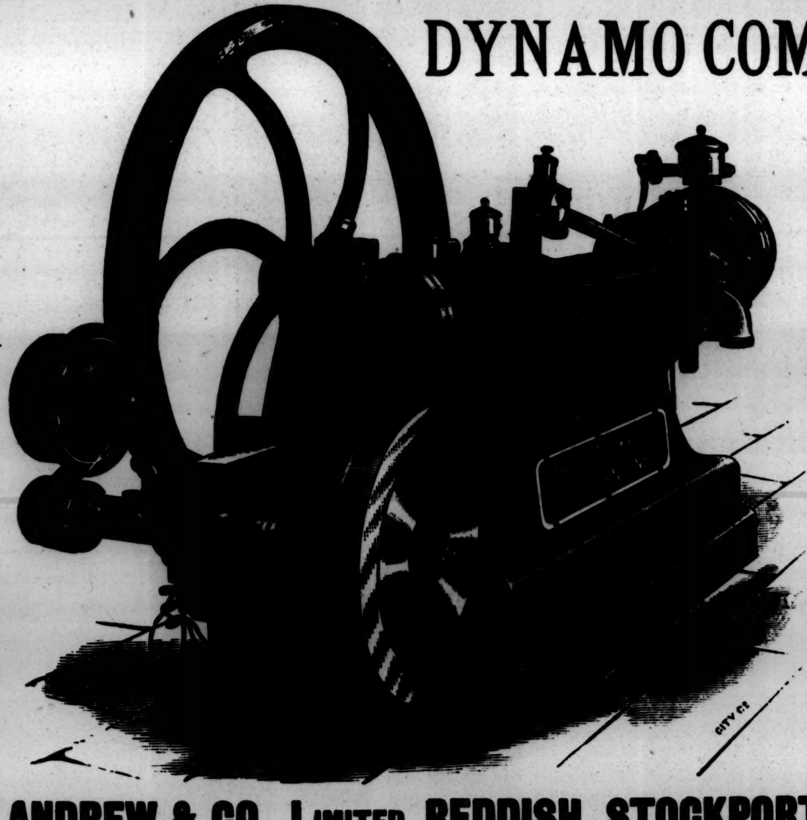

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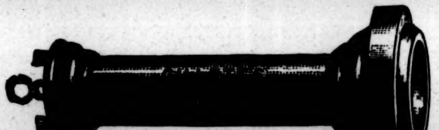

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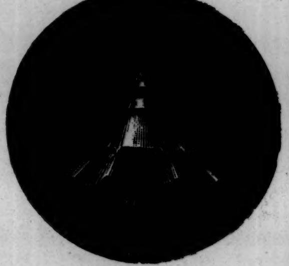

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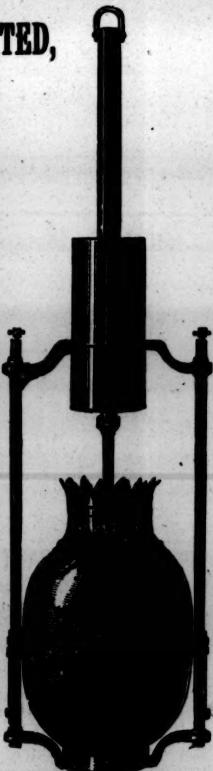

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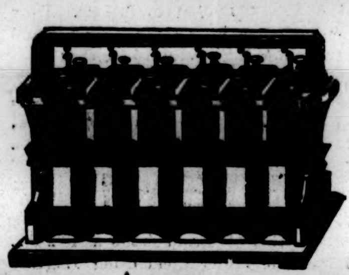

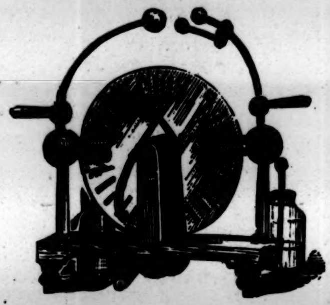

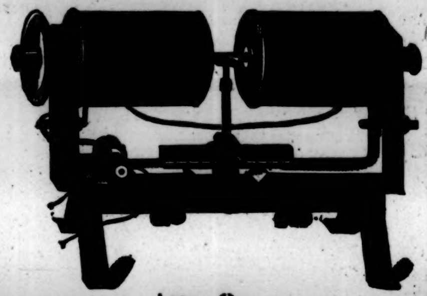

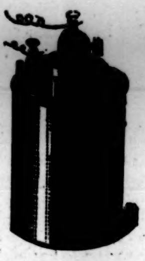

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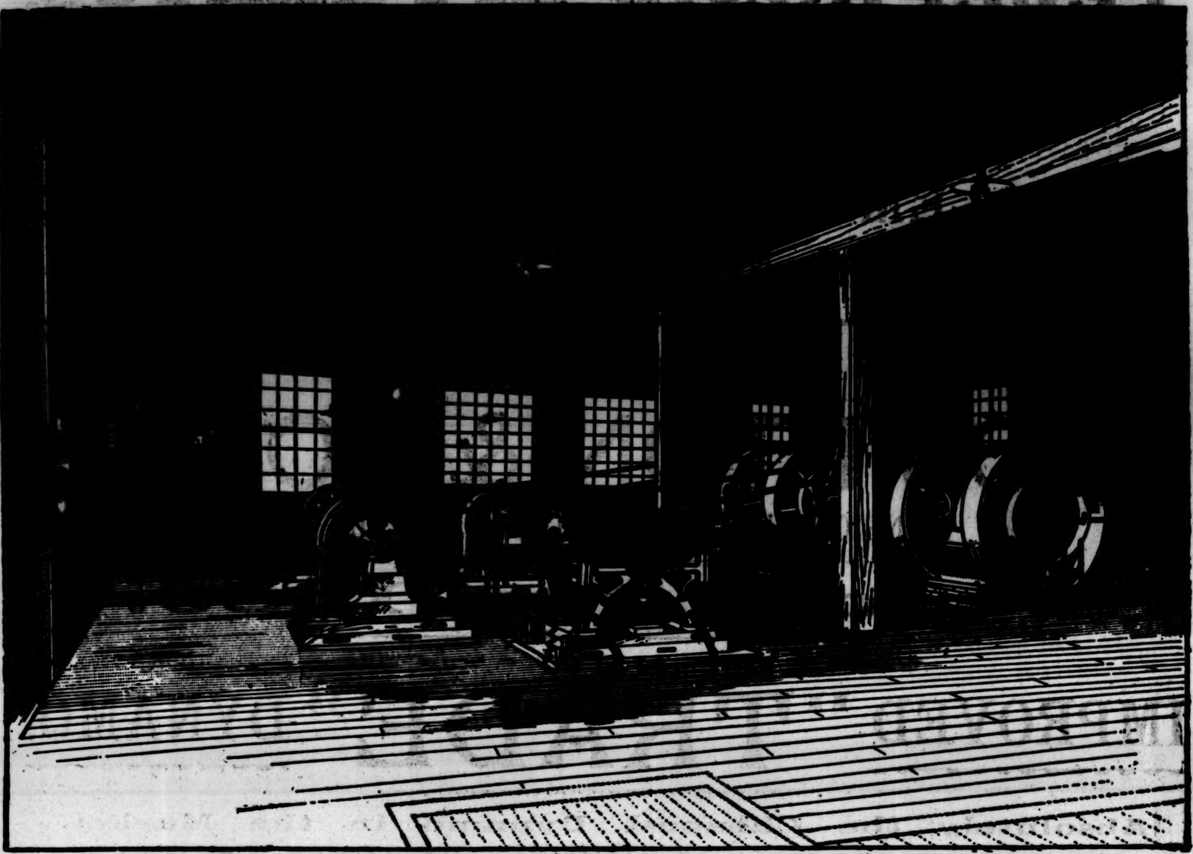

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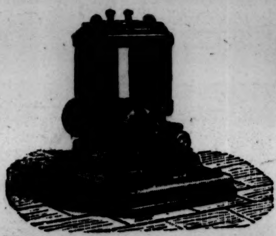

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AGENTS WANTED—SPECIAL ADVANTAGES GIVEN.

Personal.—Mr. R. J. Browne, who was assistant-electrician at Glasgow International Exhibition, has left this country to fill an important engagement in India.

Mr. Walter T. Glover is now in America, his partner, Mr. Henry Edmunds, having been very seriously ill in New York. We are glad to report that the latest news from the States is to the effect that a decided improvement is now manifest in Mr. Edmunds's condition.

What's in a Name!—The *Financial News* says:—"They beat us in company titles in the United States. There has just been registered at Chicago 'the United States Vogel Kazophone and Electric Microphone Trumpet Acoustic Electro-Motor Power Musical Car Distance Loud-Speaking Transfer Instrument Company.' The object of the company is to acquire certain patents, rent-rights, and privileges of William Vogel, Adoph Gray, and Richard Dakin. The capital is $65,000,000, which, considering the length of the company's name, is little enough.

The French Government and the Parisian Telephones.—The Chamber on Wednesday adopted the Bill for the purchase of the telephonic system in Paris, which is to be managed by the Posts and Telegraphs Department.

Electric Lighting in Sheffield.—The Electric Construction and Maintenance Company, Limited, intimates its intention to apply to the Board of Trade for a provisional order to supply electricity within the district.

Central Blatt für Electrotechnik.—We notified in our last that this journal will for the future appear weekly, and in much larger size. In its new shape it is intended that it shall not only keep the lead in Germany, but be equal to the best of its class in the world.

Jack of All Trades.—The reading of the registration of the Henley Telegraph and Electric Construction Company is very funny. That the business of a pawnbroker should go hand-in-hand with electrical engineering is suggestive enough, but things have scarcely come to this pass yet with the trade generally. What would the late W. T. Henley have thought of the works he created being spoken of as "My Uncle's?" The indefatigable Mr. Trotter has here a fine subject to report upon to the Electrical Section of the London Chamber of Commerce. The objects of the Northern Press and Engineering Company are scarcely less interesting; at all events, it can wash its own dirty linen.

Hastings Electric Lighting.—At a monthly meeting of the Hastings Town Council held on Friday afternoon last in the Municipal Buildings, Hastings, the Mayor (Councillor Stubbs) presiding, the following business was transacted:—Electric Lighting.—Notice was received that the Hastings and St. Leonard's Electric Light Company intended to apply to the Board of Trade for a Provisional Order to authorise the supply of electricity by the company for public and private purposes within the area of the authority for such period as the Board of Trade may think proper. A similar notice was received from the secretary of the South of England House-to-House Electricity Company, Limited.

Perth and the Electric Light.—At the monthly meeting of the Police Commission held on Monday night, a communication was read from the interim secretary of the Scottish House-to-House Electricity Company, Limited, intimating that that company intended to apply to the Board of Trade for a Provisional Order, to be confirmed by Parliament next session, for authority to supply electricity for lighting for public and private purposes within the city, and requesting the consent of the commission as the local authority to their application.

NEW COMPANIES REGISTERED.

Henley Telegraph and Electric Construction Company, Limited.—Capital £200,000 in £10 shares. Objects: To carry on business as electricians, telegraph engineers and contractors, submarine cable and telegraph instrument manufacturers, wire drawers, galvanisers, wire rope makers and engineers. To acquire the goodwill, patents, machinery and other property of W. T. Henley's Telegraph Works Company, Limited. To carry on the business of an electric light company in all branches. To carry on business as engineers, merchants, bankers, brokers, shippers, carriers, traders, pawnbrokers, manufacturers and contractors. Signatories (with 1 share each): F. Newton, 16, King William Street; Wm. Hays, 31, Abchurch Lane; H. Lescher, 6, Clement's Lane; Lieut.-General Sir J. Stokes, K.C.B., Good Rest, Hayward's Heath; Sydney Gedge, M.P., 1, Old Palace Yard; G. Baird, C.E., Travellers' Club, Pall Mall; the Hon. H. Stuart Littleton, 22, Rutland Gate, S.W. The signatories are to appoint the first directors. Qualification, 50 shares. Remuneration, £2,000 per annum, with an additional £150 per annum for every 1 per cent. dividend over 10 per cent. on the ordinary shares. Registered 3rd inst. by Newman, Hays & Co., 31, Abchurch Lane, E.C.

Northern Press and Engineering Company, Limited.—Capital £30,000, in £10 shares. Objects: To take over the business of the Northern Press Company, Limited, and to print and publish the *Shields Daily Gazette and Shipping Telegraph*. To carry on business as engineers, electricians, electrical engineers and suppliers of electricity for light, heat, motive power, or otherwise. To acquire letters patent granted to Robt. Cumming Annand for improvements in the inking apparatus of printing machines, and for improvements in washing machines. Signatories (with 1 share each): *James Cochran Stevenson, M.P.; *James Shannon Stevenson; Robert Cumming Annand, of South Shields; Mrs. F. M. Mackenzie, *James Annand, Newcastle-on-Tyne; *A. Shannon Stevenson, Tynemouth; Arthur Gavin Stephenson, York. The signatories denoted by an asterisk are the first directors; the company in general meeting will appoint remuneration. Registered 3rd inst. by Waterlow and Sons, Limited, London Wall.

Peru Telephone Company, Limited.—Capital, £100,000 in £5 shares. Objects: To acquire, construct, equip and work lines of telegraph, telephone, or other means of communication in Peru and adjoining countries; and to carry on the business of a telephone, telegraph, and electric light, heat and power supply company. Signatories (with 1 share each): J. D. Pearson, New Southgate, N.; H. E. Warner, Streatham Common; W. A. Pittman, 7, St. Helen's Gardens, North Kensington; H. Mann, 12, Woburn Place; S. E. Preston, W. Capel Slaughter and Wm. May, 18, Austin Friars, E.C. The signatories are to appoint the first directors; qualification, £1,000 in shares; the company in general meeting will appoint remuneration. Registered 4th inst. by Slaughter and May, 18, Austin Friars.

Ecuador Telephone Company, Limited.—Capital, £100,000 in £5 shares. Objects: To acquire and construct telegraphic, telephonic, or other means of communication in Ecuador and the adjoining countries, and to carry on in all branches the business of a telephone, telegraph, and electric light, heat and power supply company. The signatories, who are the same as in the preceding company, appoint the first directors, whose qualification is to be £1,000 in shares, and whose remuneration will be determined by the company in general meeting. Registered 4th inst. by Slaughter and May, 18, Austin Friars.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Electric Tram Car Syndicate, Limited.—An agreement of 20th ult. between this company and Alfred James Jarman, of 82, Kellett Road, Brixton, engineer, confirms an agreement of 10th April, under which Mr. Jarman agreed to sell to a company then in course of formation under the proposed name of the Electro-Motor Syndicate, certain inventions and patents for £15,000, payable £2,000 in cash and £13,000 in fully paid shares. An agreement of 13th May cites that the company referred to in the previous agreement had been registered under the name of the Electric Tram Car Syndicate, Limited, and that the said agreement should be binding upon such company. The present agreement provides for the allotment of the stipulated number of fully-paid shares to Mr. Jarman. Registered office, 31, Lombard Street, James White, Secretary.

Chelsea Electricity Supply Company, Limited.—An agreement of 5th ult. provides for the allotment to the Anglo-American Brush Electric Light Corporation of 248 fully-paid shares of £5 each, being 50 per cent. of an amount of £2,480 due to the Brush Company for plant supplied and work done for this company. The registered office is now situate at Draycott Place, Chelsea.

Tonks, Limited—(metal workers and electro-platers, and manufacturers of electric fittings).—An agreement of 9th April, filed on the 18th ult., provides for the purchase of the business and assets of Edmund Tonks and Wm. Hy. Tonks, of Moseley Street, Birmingham, for £81,039 4s. 10d., payable £45,000 in fully-paid shares, £30,000 in 4 per cent. debentures, and the balance in cash.

Northern Electric Wire and Cable Company, Limited.—An agreement of 20th ult., filed on the 1st inst., between Blakey, Emmott and Company, Limited, of Halifax, and James Duff (for this company), cites that the former have agreed to transfer to this company the machinery, stock in trade, goodwill, and all contracts connected with the electric light and telephone, cable, and insulated wire department of their business, for £4,300. The purchase consideration is payable as to £1,000 thereof in cash, and the balance in fully-paid shares. Registered office, Square Road, Halifax.

Series and General Electric Traction Company, Limited.—An agreement between the Series Electrical Traction Syndicate, Limited, and Stephen Hy. West, the liquidator thereof of the first part, Hy. Foote and Carl von Buch of the second part, and this company of the third part, cites, that by agreement of 12th January, 1888, the Telpherage Company, Limited, granted to Messrs. Foote and von Buch the option until the 29th June, 1889, to acquire several patents and patent rights with a stipulation that the Telpherage Company should be entitled to licence of such patents without royalty or other payment, provided always that the licence should only apply to aerial lines with hanging loads, and that Messrs. Foote and von Buch should have the first refusal to contract for the construction of such lines, and subject to the provision that the owner for the time being of the Telpherage line at Glynde, Sussex, shall be entitled to use such patents. The syndicate was incorporated on the 31st January, 1888, and obtained from Messrs. Foote and von Buch a licence to use the patented processes for the purpose only of traction on tramways and not on railways. The syndicate acquired a lease of tramways at Northfleet, and are possessed of certain other patents. The syndicate, in conjunction with Messrs. Foote and von Buch, have formed this company for taking over the undertaking of the syndicate, and the interest of Messrs. Foote and von Buch in the said patents. The purchase consideration is £22,500 in cash, and 40,500 fully paid shares of £1 each to the syndicate, and £12,500 cash and 29,500 fully paid shares of £1 each to Messrs. Foote and von Buch.

Electric Trust, Limited.—The registered office of this company is situate at Palace Chambers, Bridge Street, Westminster, S.W.

CITY NOTES, REPORTS, MEETINGS, &c.

Crompton and Company, Limited.

THE first annual general meeting of this company was held at Cannon Street Hotel yesterday, Viscount Torrington presiding.

The Secretary read the notice convening the meeting.

The Chairman said: Gentlemen, the directors feel they may fully congratulate the shareholders upon the satisfactory condition of the company, as shown by the statement of the accounts which has been laid before you. The company has been barely a year in existence, yet the net profits are above the average of the preceding years. It will be seen, by a perusal of the accounts, that the directors, while maintaining the plant in complete repair, have written off a sum of £1,554 as depreciation; they further propose to carry forward a further sum of £1,500 for any possible contingencies that may arise, and for doubtful debts, though this latter can hardly be expected as the accounts are not a year old. They then propose to place the sum of £568 to the reserve fund for the purpose of equalising future dividends. It may be said that this is not a large sum, still it is a beginning, and considering that the company has only been working 8 months, it may be looked upon as a fair start. In making these deductions before declaring a dividend the directors feel they are acting providently as men of business, and are doing their best to make the position of the company a strong one. It is only fair to add that the holders of the ordinary shares cheerfully acquiesce in these proposals. After setting aside this sum, the board propose to pay a full dividend of 7 per cent. upon the preference shares to 31st March, then to pay the managing directors their fees, which they are not entitled to draw until the dividend is paid on the preference shares, and, finally, it is proposed to pay a dividend on the ordinary shares of 5 per cent. So much for the past; the future looks very promising. The works are busy and orders are increasing. There is just now a great revival of the electrical industry, consequent upon the passing of the Electric Lighting Act Amendment Bill. Many new companies have been formed, and the Board of Trade have held an enquiry into the applications for Provisional Orders and licences which have been made under the Act, and has officially sanctioned many of the projects. Manufacturers are consequently very busy, this company, in common with others, having a large increase of orders. The directors believe that a very prosperous future is before them, and every effort is being made by the careful attention to details to ensure that the work shall be executed in such a manner as to keep the company in the front rank of reliable makers. The circular and prospectus of the Australian Company, referred to in the report, have been sent to the Press, and these papers fully explain both the objects of the new company and the reason for its formation. We believe that this Australian Company has every likelihood of being a properous one. Messrs. Harrisson and Whiffen have done good work in Australia, and the business has grown rapidly; directors have every confidence in recommending subscriptions for the shares of that company. I may mention that the Australian Company which has been formed, and over which I have agreed to be chairman, is merely another form of having a house in Australia where our business will be transacted, perhaps better than if we had a firm out there to look after it. The Australian Company are bound to get all their materials from the parent company. At the date of the report only 16,781 shares were allotted, but up to this date the shares placed number 18,816; there are less than 1,200 left, and these will no doubt be placed very shortly. I think it is a question whether we ought to put a premium upon the balance that we have still left; but that is a matter which the directors will take into consideration. There is a question which has appeared to be somewhat knotty to some of our shareholders, and that is the question of patents and goodwill for the sum of £37,765. That is the value of the goodwill and patents; it represents a value of the business for the realisable assets handed over to the company by the vendors. I have no doubt the secretary will answer fully any questions as to this. I move then that the report of the directors and audited statement of accounts be adopted.

Mr. Crompton, in rising to second this, said: I have great pleasure in addressing you for the first time since the formation of the company, as I was unfortunately absent from the first meeting. To me it is a somewhat nervous moment, being the original founder of the business which is now turned into a limited company. As a private concern I was very proud of it, and I am and shall continue to be equally proud of it as a limited company. There has been among some people a sort of prejudice against the Limited Liability Company Act; they say that firms which have done extremely well as private firms do not continue to do so when turned into companies. That is a statement which has been often made, and in some cases it is only too true, but some of the finest businesses in this country are worked on the lines that we are working this company, that is, the original founders who have built up the business remain the principal shareholders. When I look to such a firm as Marshalls, of Gainsboro', the finest engine works in the world, I only hope we shall follow in their footsteps and have our name so well known. I am sure that the objects we had in view in obtaining the additional capital by the formation of the company have been partially attained. We have been able to take up many large contracts which we could not have dreamt of doing so long as we were hampered by the lack of capital, and as a result each order is better executed than from the time this business commenced. I quite corroborate what the chairman has said for the future prosperity of the company. We are doing our best to increase the number of companies, and are negotiating with several towns in addition to those named in the report, but, for reasons which we all appreciate, we do not name these towns here, as they are not absolutely completed, and our rivals are apt to step in and snatch the cup away before we get it to our lips. I have said all I think is necessary, and conclude by seconding the chairman's motion.

Mr. Tufnell asked what was the percentage of depreciation charged upon the plant, building, &c. He considered the sum of £15,554 appeared, at first sight, rather small.

Mr. Reeves (secretary) said 2½ per cent. had been written off the building accounts, and 7½ per cent. off the plant and machinery, which was ample considering they maintained the building in full repair.

Mr. Allbright, who was called upon by the chairman, said: I did not contemplate that I should have been called upon to speak, but as our chairman has asked me I am very pleased to have an opportunity of addressing you. I will give you an incident which occurred this morning which may interest you. An engineer on one of the most important railways in America called upon me this morning, and referred to a certain order which had been recently placed with us. He incidentally mentioned that the plant which we had supplied to them upwards of two years ago had already considerably more than paid for itself in the saving which had been effected by using the electric light. They could now unload waggons, and, generally speaking, carry on their business by night as well as by day, and he further remarked that our plant was so satisfactory that although lower tenders than ours had been submitted, there was no hesitation whatever in going back to the people from whom they had had satisfaction in the past.

The motion was then put to the meeting, which was carried unanimously.

The Chairman said since the formation of the company they had put upon the direction two gentlemen whose names would be well received, Mr. Bernard Gibson and Mr. C. F. Tufnell. He would like the meeting to confirm their appointment.

The Rev. O'Brien Hodge moved, and Mr. J. Hill seconded their election, which was carried unanimously.

Messrs. Duncan Bryce & Co. were re-elected as auditors.

A vote of thanks to the chairman brought the meeting to an end.

India-Rubber and Gutta-Percha Company.

THE half-yearly meeting of this company was held yesterday at Cannon Street Hotel, Mr. S. William Silver in the chair.

The Secretary read the notice convening the meeting.

The Chairman then said: I may say we have pleasure in meeting you here to-day, and that we have to report to you that the general trade has been quite equal—somewhat in excess of any previous year. Our electrical and telegraph departments have been fairly occupied; the steamers, too, have been employed, one returned only last Saturday after laying a little short of 1,000 miles on very difficult ground. The expedition, under the direction of our engineer-in-chief, Mr. Matthew H. Gray, was successful in every respect, notwithstanding the peculiar character of the coast; the mouth of the Congo River delta, and the varying nature of the work all showing us, and the public generally, that a practical knowledge of the manufacture of the cable is not only desirable, but essential, to carry out such an undertaking as this successfully. I may take upon myself to say that in uniting practical knowledge with scientific skill, the Silvertown Works will not be found wanting. I think, on behalf of my friends, I am justified in moving that a 5 per cent. dividend, or 10s. per share, free of income tax, should be payable.

Mr. Matthew Gray seconded the motion, which was carried without dissent.

Mr. J. L. Harrison moved, and Captain Verey seconded, a vote of thanks to the chairman and directors for their efforts, which was carried unanimously.

The proceedings then terminated.

The Crompton Electric Supply Company of Australia, Limited.

THE capital of this company is fixed at £50,000, in 9,500 "A" shares and 500 "B" shares of £5 each, the "B" shares not participating in the profits until 10 per cent. is paid on the "A" shares, after which they are entitled to one-half of the surplus. Subscription is now invited for 4,000 "A" shares, more than one-half of which are already subscribed.

The prospectus states that "the well-known firm of electric light engineers and contracters, Messrs. R. E. Crompton & Co., of London and Chelmsford, have established, through the assistance of their agents, Messrs. Harrisson and Whiffen, of Sydney, Adelaide, and Melbourne, a sound and rapidly increasing business in the Australian Colonies.

"It is well known that electrical work is extending enormously, and the colonists are fully alive to the many advantages of the electric light. The amount of work in progress and the importance and magnitude of the orders and proposals lately received by Messrs. Harrisson and Whiffen necessitate the introduction of additional capital. It is therefore proposed to form this company for the purpose of supplying the capital necessary to further develop this profitable business, and Messrs. Harrisson and Whiffen themselves subscribe for one-fourth of the present issue of the "A" shares, Messrs. Crompton and Company, Limited, subscribing for a like amount.

"In the case of many orders received payments have to be taken by instalments spread over 12 or 18 months; and some of the *now proposed contracts* are so large that it is imperatively necessary more capital shall be available to guarantee the execution of the orders. The general business of electrical engineering has greatly increased during the last year or two, and large profits are at present being made from this work.

"Messrs. Crompton and Company, Limited, have granted to this company during the continuance of the agreement specified below, the exclusive right of representing them in the Australian Colonies and Tasmania, and have undertaken that they will not, without the consent of this company, supply electricity or electrical plant or machinery in those colonies, except through this company, and they agree to allow this company favourable terms in respect of price. They have also undertaken to give to this company, in manner more fully described in the agreement, the benefit of their existing patents in the Australian Colonies. Two members of their board become directors of this company.

"Messrs. Harrisson and Whiffen agree to continue as agents for the company, under the directions of the Australian Committee. They are to be paid for their services by a small fixed commission upon the amount of the company's receipts, and in consideration of this commission, Messrs. Harrisson and Whiffen are also to defray the expenses of the company's office and staff in Australia, other than the engineering staff. This agreement with Messrs. Harrisson and Whiffen, therefore, will have the effect of limiting the working expenses of the company to an amount proportionate to the actual business done.

"The company enters at once into the possession of a going business, with estimated profits of a considerable amount attached to the contracts. The consideration agreed to be paid for the sale of the business, and for the exclusive right to sell the electric appliances of Messrs. Crompton and Company, Limited, in Australia, is 500 "B" shares of £5 each, issued as fully paid. These shares will not participate in the profits of the company until 10 per cent. is paid on the "A" shares. Messrs. Harrisson and Whiffen are also to receive payment in cash for the plant, machinery and stock in trade, which is to be taken over by the company.

"The contracts entered into are one dated the 24th June, 1889, and made between Messrs. Harrisson and Whiffen of the first part, Crompton and Company, Limited, of the second part, and the company of the third part, and another of the same date, made between Messrs. Harrisson and Whiffen of the one part, and the company of the other part. It is not practicable to give particulars in this prospectus of all the trade contracts which have been entered into by Messrs. Harrisson and Whiffen, and applicants for shares must therefore waive the specification of such particulars. The two contracts mentioned above, together with the memorandum and articles of association, may be seen at the offices of the company's solicitors, Messrs. Deacon, Gibson and Medcalf, 4, St. Mary Axe, London."

The National Telephone Company.—Mr. Frederick R. Leyland has been elected president, and Mr. Forbes and Col. R. Raynsford Jackson vice-presidents, under the new organisation, and the following gentlemen directors—Charles Swain Agnew, John Winterbotham Batten, James Brand, John Bruce, Peter Garnett, Eli Heyworth, Joseph Bond Morgan, Dillwyn Parrish, William Cuthbert Quilter, M.P., George Hunter Robertson, Samuel Herrick Sands, and Alderman Joseph Thompson.

The Edison and Swan United Electric Light Company, Limited.—The directors have had the accounts for the year ending 30th June, 1889, before them, and subject to audit, they have decided to recommend, at the meeting of shareholders to be held on 30th inst., a dividend of 7 per cent. for the year on the "A" shares, and a further distribution of 3 per cent. against arrears of cumulative preferential dividend on those shares.

The West Coast of America Telegraph Company, Limited.—At a board meeting this week, the directors of the West Coast of America Telegraph Company, Limited, declared an interim dividend of 5s. per share, free of income tax, in respect of the first half of 1889, payable on the 18th inst.

TRAFFIC RECEIPTS.

The Brazilian Submarine Telegraph Company, Limited. The traffic receipts for the week ended 28th June, 1889, amounted to £3,126; and for the week ended 5th July, 1889, amounted to £4,068.

The Cuba Submarine Telegraph Company, Limited. The estimated traffic receipts for the month of June were £3,300 as compared with £3,037 in the corresponding month of last year. The receipts for the month of March, estimated at £4,500, realised £4,540.

The Great Northern Telegraph Company, Limited. The receipts in June, 1889, £22,600; January 1st to June 30th, 1889, £129,400; corresponding months, 1888, £132,000; and of 1887, £127,120.

The Western and Brazilian Telegraph Company, Limited. The traffic receipts for the week ending 5th July, 1889, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £2,791.

PROBLEMS IN ELECTRIC TRACTION.

By Dr. LOUIS BELL, Purdue University.

THE preliminary stage of electric tramways is to-day quite gone by. While three years ago such an application of electricity was regarded very dubiously, that doubt is now displaced by the certainty that the electric road is a success and has come to stay.

The live question to-day does not involve the chances of the electric road but the chances of its competitors. There are now something like 50 electric roads in regular daily operation in the United States, covering about 200 miles of track, employing all sorts of systems, working under all manner of adverse conditions, climbing grades of pitch equivalent to 400 feet and 500 feet to the mile, taking curves of all possible radii, and there has been with all this no report of failure anywhere.

On very many of these roads electricity has replaced horses, and nearly every week brings reports of similar substitutions elsewhere.

No inroads have as yet been made on the cable systems, but it is an open question whether they can hold their own, even in the favourable localities where they are already established.

No one need ask, in face of these facts, whether electric traction is practicable or successful, but rather such questions as these: How efficient is it? What is its first cost, compared with horse or cable traction? How do its running expenses and repairs compare with these? What grades and curves can safely and economically be taken? What accidents is it liable to, and how can they be prevented? What are the conditions of efficient and economical running?

It was for the purpose of attempting to answer some of these vital questions that the present investigation has been carried on.

To obtain thoroughly practical results applicable to the everyday working of an electric tramway I have not concerned myself with theoretical motor tests and curves such as are detailed in Mr. Sprague's now famous paper on his Richmond road, but have confined myself quite closely to actual car tests of power and efficiency, and to the evidence of the ammeter and the indicator diagram at the power station. I do not at all underrate the value and importance of the above-mentioned theoretical curves, but that ground was so thoroughly covered in the paper in question that a repetition is needless. Furthermore, the man who contemplates putting his money into an electric road does not particularly care about the characteristic of the motor used, but he does want to know how much power must be developed on his cars, how much coal he must burn at the power station to obtain it, what efficiency he may expect from the system, what are its weak points, and how they may be strengthened.

Through the kindness of Mr. Hawter, superintendent of the La Fayette (Ind.) Street Railway, every facility has been afforded me for making a thorough and detailed test of the road, and such of the results as may properly be published are recorded in this paper, only such details as directly concern the private business of the company being omitted.

Before taking up or discussing these experimental results, I purpose considering the general conditions under which electric roads must operate, the general difficulties to be met and the relations of this method of rapid transit to those with which it has to compete. There are many requirements for street railway work which are not met with in any other kind of traction. For most of these the electric motor is admirably adapted, while for a few it is not. Consider, then, the conditions to be met in street railway work and the properties that a motor of any kind must have to be thoroughly suited to these conditions.

1. To meet public convenience a tramway line must in nearly every case run through the most frequented business streets of a town, and outside the business portion must pass through, or very near to, the thickly populated residence streets and on to the larger suburbs. It, therefore, is generally not at liberty to pick out a route of the easiest grades and curves, but must be able to surmount quite severe grades readily, and take without much danger of derailment any curves that the streets require, sometimes of radii barely above 20 feet.

2. It should be thoroughly reliable, *i.e.*, track and motor system should be so constructed that the system will be of very little danger, first, of a complete breakdown, interrupting travel throughout the line; and, second, of local accidents sufficient to pile up cars at any particular point.

3. It should have a considerable flexibility in the matter of speed. In any line where the cars run on anything like a fixed schedule, as will always be the case in anything except the very largest lines, they must be able to make up lost time within reasonable limits in case of a trifling accident or unusually frequent stops. For this reason the maximum speed should be considerable.

4. It must be able to stop and start quickly and easily. Running through crowded streets and liable at any moment to find its tracks blocked, the only security against serious and frequent accident is in the ability to stop quickly, even when running at full speed. Easy and quick starting, too, is quite necessary, since so much of the running time is taken up in just this way.

5. Track and motor system should be of such a kind as will cause the minimum amount of obstruction to the streets and annoyance to the travelling public. For this reason the rails are very low and unobtrusive, consequently somewhat less secure. Since most of the traffic is and will continue to be carried on by means of horses, any system that renders it difficult or dangerous to drive in the same street is open to objection.

6. The motor system should be tolerably silent, and of such a kind as not to prove a nuisance to the streets through which it passes. This condition and the last practically preclude the use of anything like the usual steam motors, except in the rare cases where the line can be carried through unfrequented streets.

7. It must be so arranged as to meet readily the demands of an unusual crowd at some one point. It frequently happens that most of the cars of a system must be started under nearly full load within a few minutes. This is specially true of lines connecting with suburbs, where the traffic is likely to be very uneven.

With all this, any tramway system must be tolerably economical in operation, and its first cost must not be prohibitive.

These conditions cover most of the points in street railway work, although in special cases they may be considerably modified. To meet these requirements all sorts of devices have been brought out. Of course, the use of horses is the principal method even now. Next in order come those motor systems which are modifications of the ordinary locomotive; then the cable traction systems, and finally the various electric systems. We have no concern here with the second class of motors above mentioned; they occasionally serve a useful purpose, but for every day use in crowded streets they have been adjudged by common consent a nuisance.

Taking, then, the three systems in extensive use, let us see wherein they do, or do not fulfill, the above conditions, specially seeking out the weak points and difficulties of the electric systems.

So far as grades are concerned, the cable system easily takes first rank, for its power of hill climbing is limited only by the power of the grip and the tensile strength of the cable. The grip is usually of the toggle joint form, and consequently, if necessary, a cable car can be made to take a grade practicable for nothing else except a cogwheel road. Of course such excessive grades are neither desirable nor economical but now and then they are almost unavoidable. Sharp curves can, of course, be employed on a cable system, but with disastrous effect on the life of the cable and the efficiency of the system. The wear and tear on a cable with many curves is very severe.

With horses very steep grades are exceedingly objectionable, but by the aid of hill horses can be taken, except in slippery weather. At best horses are far inferior to the cable system for grade work, though a horse car can safely take a curve that nothing else can, for the horses tend to guide and pull round the head of the car, while in any motor system there is a certain tendency to jump the track even in spite of guard rails.

With electric roads the case is quite different. The motor cars depend on adhesion alone for hill climbing, and beyond a certain point adhesion fails. In such a car, however, the whole weight of car and contents rests directly upon the driving wheels in most cases, and consequently theoretically the possible grade per cent. should be numerically equal to the coefficient of adhesion. This can hardly be estimated exactly except by experiment in a given case, and street car tracks are generally not carefully enough laid to give good results. The data obtainable, however, would assign something like 20 per cent. as the maximum practicable grade and the real limit probably lies below this. As to the evidence offered by actual experience under working conditions, it is certain that with proper care of the track grades as high as 400 feet per mile can be operated with entire success. This presupposes that the rails are kept in good order and clear of sleet and snow. With extra vigilance in this respect, aided now and then by a little sand, I think it would be feasible to take grades of 500 feet per mile if necessary. Above a 10 per cent. grade the case is rather precarious when we consider the effect of rough weather. Occasional grades of greater pitch may be taken if they are not too long and conditions are favourable. As to curves, the electric roads are practically unlimited, but curves on grade are particularly undesirable, and in any case the speed should be reduced and the track well supplied with guard rails. Save on a steep grade there is no likelihood of trouble.

As regards reliability, one may divide the various systems into two general classes—those in which each car is an independent unit, and those where all the cars have a common source of power. The former class comprises horses and the electrical accumulator system; the latter, cables, and all other modifications of electric traction. All traction systems are liable to occasional local mishaps, but a general breakdown is very improbable in the first class, while in the second it is likely now and then to occur. In the cable system this is most likely to be caused by breakage of the cable itself, either as a whole or in part, *i.e.*, the snapping of one or more strands. In the former case the system is paralyzed until the cable can be repaired, a period usually of several hours; while if the trouble comes from a broken strand or two, the loose wire can be cleared away in a few minutes and the cable run until stopped for the night, when a new strand can be inserted.

With the usual electrical systems a general stoppage, except in very rare cases, is due to a single cause, a serious short circuit at some point on the line. The wiring is usually arranged so that a broken wire, aside from the contact wire, causes no serious trouble, and even if the contact wire breaks, only a short section of track is thrown out of service. If a bad short circuit occurs, however, it may become necessary to shut down the entire line. But such an accident can be remedied almost as soon as the scene of it can be reached, and a broken wire is very easily mended. Electrical roads are, however, quite liable to minor accidents to single cars. Brushes will turn, trolleys will come off, gears will occasionally break, field coils will now and then burn out and local short circuits occur. Most of these mishaps can be soon remedied, and not a few of them averted by a vigilant system of car and line inspection. In fact, I think it would be quite safe to say that three-fourths of these local accidents can and should be prevented.

Great power of varying speed is one of the characteristic advantages of the electrical systems. The speed may range from four or five, to fifteen miles per hour at will, each car being separately driven and controlled. As the ordinary running speed is considerably below the maximum, trains can be made up quite readily, and the speed lowered very much in crowded streets without resorting to stops and starts. Horse cars possess something of the same flexibility, but their maximum speed is so low that with modern needs for rapid transit the horse car must eventually disappear. As is well known, cable roads work virtually at a fixed maximum speed and can only slow down by letting go the cable.

The same qualities that give an electric car a widely varying range of speed give it also the power of starting very smoothly and easily. In this respect it is decidedly superior to the cable cars, which, although they can be made to start with tolerable ease, usually do not. In addition, the electric car possesses an almost unique power of stopping suddenly in case of need. In a crowded street, it not infrequently happens that man or beast slips directly in front of a moving car. With horses or cable, many accidents have resulted. With the electric car, however, the cases would be exceedingly rare in which a prompt reversal of the motors would not avert such a result, for if there is need, an electric car at full speed may be stopped within its length. I have seen a horse fall on the track within a few feet of a car at ordinary speed, and the car brought to a standstill without touching him. A man has been knocked down by the dashboard and the car stopped before the wheels reached him. Of course, such sudden stoppage is only attempted in case of dire necessity, but when that necessity comes it can be and is done.

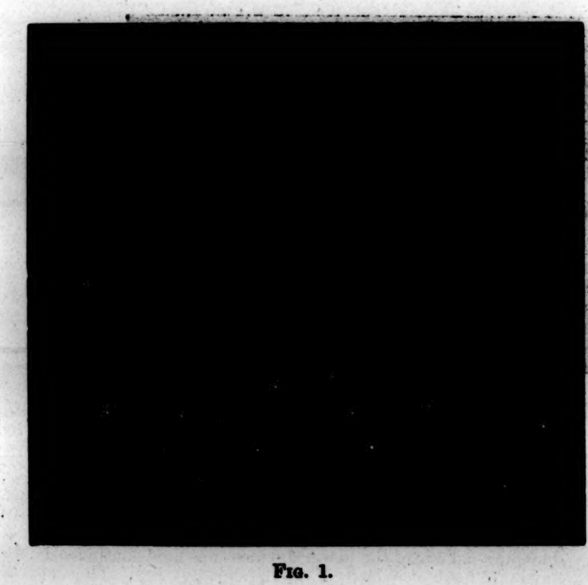

FIG. 1.

VARIATION OF CURRENT, LAFAYETTE, IND., ELECTRIC RAILWAY.

So far as track is concerned, all tramway systems have about the same requirements. In the case of all motor cars of whatever kind there is more or less trouble from frightening horses, and, for a time at least, making the streets dangerous to drive upon. Every place in which a motor system has been started can show a record of a rather serious kind. It is certainly an important consideration. Horses, however, soon become used to motors, and the main difficulty is only temporary. But all overhead electric systems, and all using the rail as a part of the circuit, are especially likely to scare horses on account of the frequent flashes from trolley or rails, or blazing at the brushes. I have known horses supposed to be thoroughly used to electric cars to become frightened at a brilliant flash and shy at the cars for some time afterwards, even dodging one drawn by a couple of innocent mules. With proper care of line and track, the flashing can be much diminished, however, and with care the difficulty is not at all so serious as might at first appear.

As regards noise, electric and cable cars are at present not widely different. In the electric systems the incessant grinding of the cable all along the line is absent, but the noise of the gearing is often considerable, particularly after it becomes worn. At present gearing seems the most feasible method of reducing the speed of the motors, but, except when new, it is far from silent. The noise, however, of either cable or electric cars is not so great as to constitute a valid objection to their use.

With a proper plant, any of the electric systems can handle traffic massed at one point in a way that leaves little to be desired.

Aside from the general conditions to be met, an electric road encounters certain difficulties quite peculiar to itself, some of them real, others rather to be classed as imaginary. In the first place there is a widespread popular delusion that the overhead wire in general use is exceedingly deadly, and that the track used as return circuit is scarcely less so. As a matter of fact, the maximum potential used in tramway work, 400—500 volts, cannot be classed as even dangerous. It would, of course, be decidedly unpleasant to receive the full effect, but there is no reason to believe that it would imperil life or cause a more serious injury than burns at the point of contact. In fact, a large number of *employés* of electric roads have received the full E.M.F. without injury. In addition the wire is carried so far out of reach that the public cannot get at it, and even if it falls it is soon gotten out of the way. The track return is perfectly harmless. These facts are well known wherever an electric road has been in operation for any length of time, but the use of very high potentials for arc lighting has given the electric current a popular notoriety that it does not deserve.

It is, nevertheless, quite clear that the overhead system must be abandoned in large cities, except in some few special cases. Eventually all wires must and will go underground in such situations, and electric tramways, like electric lighting systems, must face the difficulty. That this difficulty is a real one no one who has watched the progress of underground work will care to deny, but the ostentatious collapse of certain electricians under the weight of the problem is hardly in keeping with the skill and readiness they have heretofore displayed.

Fortunately the case for tramways can be easily solved either by a conduit or storage batteries. Which of the two will furnish the ultimate solution of the problem depends mainly on the progress made in accumulators within the next few years. Could the accumulator be reduced to a reasonable weight it would certainly furnish the ideal method of electric traction.

There is one question, however, that is of great and growing seriousness in electric traction, and that is the interference of an electric tramway of the ordinary type with the telephone lines in the vicinity. First, there is the danger of a cross circuit between their respective wires where the damage will be all on one side; and second, the fact that an electric tramway using ground connections may quite paralyse all the telephone circuits in the immediate vicinity. The first danger may be in great measure avoided by a proper system of guard wires, but the second difficulty is of no small moment, and cannot so easily be met.

The effect of a traction line on all neighbouring telephone lines is very marked, in some cases rendering them almost useless. The exact nature of the phenomena produced is very complicated. Listening at a telephone thus affected, it is possible to follow in considerable detail the operation of the motors. Whenever a car is started, a low hum is heard, gradually rising in intensity and pitch as the speed increases, and as the connections are shifted from step to step on the switch box. Beneath this distinct note is a confused whirring sound of lower pitch and greater intensity. The effects are clearly due to the superposition of several different periodic variations in the current and electromotive force on the traction line. The transference of this disturbance to the telephone line depends on two quite distinct causes; first, the direct effect of induction; and second, the disturbance due to the fact that both systems are grounded at points not very far distant from each other. The relative importance of these two causes varies very widely in different places. Here most of the trouble comes from direct induction, while it is not uncommon to find nearly all of it coming from the grounds. Both causes must in general be eliminated to avoid the difficulty.

Examine first the cause of the fluctuations which produce induction. Any motor the armature of which is wound in a finite number of sections must, in the first place, produce sinusoidal variations in the motor electromotive force. These, however, are of small amplitude, less than one-half per cent. in motors generally used, and are in this case of minor importance. Their period corresponds to N, n per second, where N is the number of revolutions per second and n the number of segments in the commutator.

Besides this there is a periodic variation of the ohmic resistance of a motor due to the fact that the brush in sliding from segment to segment momentarily short circuits the ends of an armature coil.

Let n be the number of armature sections and r the resistance of each, R_1 the resistance of the armature from brush to brush, and R_2 the resistance of the series field coils. Let the motor be supplied, as is usual, in practice at a constant electromotive force. Then, assuming the brushes to be 180 degrees apart and touching one segment the resistance of the motor is—

$$R = \frac{n\,r}{4} + R_2.$$

Now, revolve the armature until each brush touches two segments, and—

$$R = \frac{(n-2)\,r}{4} + R_2.$$

Therefore when the motor is running at a constant speed the current will be subject to fluctuations of amplitude determined by the above, and occurring n, N times per second.

Take, for example, the ordinary Sprague motor where $n = 24$, $R_1 = 1{\cdot}2$, $R_2 = 3{\cdot}3$ (last step) $r = {\cdot}2$, the amplitude of the fluctuation is somewhat over 2 per cent. of the normal current.

As the cars are fitted with two motors in parallel, if the two sets of brushes short circuit simultaneously we should have a double effect and a variation of 2 per cent. in the total current through the car. If they do not short circuit simultaneously, a variation of half the amount 2 $n N$ times per second.

Another small periodic disturbance is due to the fact that the brushes are very generally unsymmetrically placed, with the result that the motor electromotive force in the halves of the armature will be slightly unequal. The result is as if a weak alternating current were acting in the armature with 2 $N n$ alternations per second.

Another and more serious difficulty occurs when the insulation between the commutator segments is somewhere near the width of the contact edge of the brush. In this case there would be produced a fluctuation which might almost amount to a make and break, and would have N periods per second if the brushes were symmetrical, and 2 N if they were not. The fluctuations due to this cause are frequently considerable. Add to this the possible irregularities in the commutator contact, and we have a combination of sinuous and alternating disturbances of an immensely complicated kind.

Of course, the remedy for induction is well known—giving the offending current a return wire, so placed as to neutralise its effect, or adopting a similar process with the line disturbed.

The case of earth disturbances has recently been investigated by Mr. Preece (*The Electrician.* Vol. XXII., p. 618). His results show that the effect of a grounded sinusoidal current may extend to a great distance and may cause very much worse disturbance on a telephone line than simple induction.

These facts would suggest that in all electric traction work a complete metallic circuit should be used, and that grounding *via* the rails should be avoided.

remain very small throughout any compact system of wires. It would be practically very difficult to secure compensation with fewer conductors than four so long as two of them must be approximately fixed. This four-conductor system could be applied to existing lines with small trouble and expense.

I will now pass to the efficiency tests made on the electric road in this city.

The Lafayette Street Railway Company operates 3·6 miles of single track on the Sprague system. The line was operated by horses until the summer of 1888, and has now been operated as an electric road about eight months. The track is a branching one, extending on both sides of the Wabash River and reaching well out to the city limits. The grades are in some places severe. In the central part of the city which lies in the old river bottoms the grade is very light, but on the east side the road rises sharply, taking at first a slight grade and then one of about 6·6 per cent. and fully 800 feet long, averaging 7·34 per cent. for 100 feet in one section. On the west bank of the Wabash the road rises over the bluff, taking a 6 per cent. grade for about another 800 feet, with a very sharp curve near the middle point. There are more than a dozen curves in the road, most of them of a rather short radius.

There are seven motor cars, of which six are in continuous use. The cars are closed, weigh complete about 5,200 pounds, seating 20 persons readily, and holding at a pinch between 40 and 50.

The plant combines a plant for stationary motors with that for the street cars. There are two of the regular Edison railroad dynamos coupled in parallel, each having a normal capacity of about 30,000 watts at 500 volts, or rather more in case of need. Two other Edison dynamos of about half the capacity supply the power circuit at a potential of about 250 volts.

Power is supplied by a Hamilton Corliss engine, 14 inches by

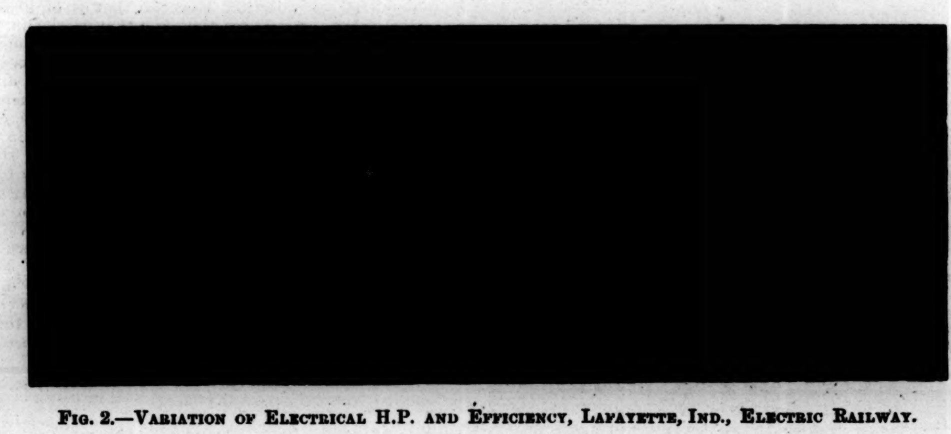

FIG. 2.—VARIATION OF ELECTRICAL H.P. AND EFFICIENCY, LAFAYETTE, IND., ELECTRIC RAILWAY.

Double contact wires, however, are certainly objectionable where they have both to be supported by a system of wires, both as being somewhat troublesome mechanically and as being unsightly. Unless guarded with great care they will much increase the danger of troublesome short circuits. Where, however, they can be supported on brackets, and hence more efficiently guarded, their use should furnish an effective way out of the telephone difficulty.

But in very many cases it is desirable to use the single overhead wire, and some simple means of avoiding at once earth and induction is desirable. Clearly it is not sufficient to use the track alone for a return or the track with an auxiliary wire beside it, as is quite usual.

For the current of supply is, or always should be, divided between the trolley wire and a line wire connected with it at intervals, hence the inductive effect of this overhead system can never be balanced by an equal current along the ground by reason of unequal distance from the overhead telephone wires.

I would, therefore, suggest the following as perhaps the simplest and easiest way of abolishing the induction: Connect the rails so as to form a return circuit leading either back to dynamo or to a main earth at some unobjectionable point. Then remove the auxiliary wire from the track to form a second return circuit parallel to the line and nearer than it to the telephone lines. Finally connect these two return systems at any convenient number of points by wires under the surface and up the nearest pole. Neither track nor these cross wires need be carefully insulated.

The supply current then is divided between line and trolley wire and the return between auxiliary line and track. The most of the former current would pass along the line wire and most of the latter along the track. Since the coefficients of self-induction will be quite nearly equal, the disturbing fluctuations will divide in the same ratio as the currents, and we have a system of four conductors in which the two fixed ones, trolley wire and track, nearly neutralise each other, the larger current being the more distant from any overhead wires; while the two movable factors, the two-line wires, can be so arranged as to complete the compensation. Given the resistances, such a system can be easily arranged, so that the resultant induction on any single wire would be *nil*, and 36 inches, running at 88 revolutions per minute. Two large horizontal tubular boilers furnish steam at a normal pressure of 85 pounds, and have a large margin of capacity. The two railroad dynamos and one of the power dynamos are used continuously, the former 16 hours, the latter 10 or 12 hours per day. The first car leaves the end of the road at 6.20 a.m., and the last car gets in at 10.20 p.m. Each car makes from 35 to 40 miles per day, is operated by a single man, and can, if necessary, take one of the spare cars in tow to accommodate an unusual crowd.

The first tests were made at the power station, with the object of determining the actual electrical output on the road, the indicated horse-power necessary to produce it, and the amount of coal required. To this end the engine was indicated every five minutes throughout the day, beginning and ending this series with a group of friction cards. Meanwhile the electrical output was simultaneously obtained from volt and ampère readings. The volts were read on an Ayrton and Perry voltmeter, and the ampères on the station ammeter, which was afterwards checked, as well as practicable, by a new Ayrton and Perry ammeter. The coal burned during the test was measured and its weight determined.

The results of the friction cards were as follows:—

Friction of engine + 3 dynamos average: Morning, 12·5 I.H.P.; night, 19·1 I.H.P.

A number of cards taken on different days gave almost exactly 16 I.H.P., which we may take as a fair average for the power wasted in friction. The dynamos are all belted to a main shaft, which is driven by a belt from the engine.

This shaft is well in line and kept in good order. In fact, the station is a model of neatness and the machinery is looked after with unusual care.

These figures give for the approximate friction of the engine alone 12—14 I.H.P. In other words, we may take the engine friction as 10 per cent. of its rated full power.

The five minute indicator cards were worked up very carefully, and gave as the average continuous power throughout the day 39·05 I.H.P. The highest figure reached was 79·3 I.H.P., and from this figure the power fell to the friction cards as a minimum.

In a similar way the readings of volts and ampères were combined and showed an average that was remarkably low, being 10,881 watts, equal 14·58 E.H.P. The greatest output recorded was 90 A., 410 V., 36,900 watts, equal 49·46 E.H.P. This figure was reached only for a few seconds. This is not as great an output as is sometimes observed on the line, where occasionally 75 E.H.P. may be demanded, though such a call for power is quite unnecessary under ordinary working conditions. The ammeter readings not infrequently fell to zero for a few seconds at a time.

To obtain the total electrical horse-power for comparison with the indicated horse-power, we must add to the above the amount obtained by a similar approximate integration of the power used on the stationary motor line, which was 1·25 E.H.P.

The ampères on the car line varied from 0 to 90 and the volts from 405 to 480, averaging about 450. A sudden call for a large current invariably lowered the potential to about 410 and tended to slow the engine momentarily, for the governor only began to act some two seconds after the current rose; and so sudden are the variations in current that nothing short of compound winding can possibly keep the dynamo at anything like constant potential.

The electrical output varied greatly during the different hours of the day. Fig. 1 gives this variation of the output with the time in a very marked way. The heavy line gives the E.H.P. required hour by hour. The variation is very large, and causes a similar variation in the efficiency of the power station, since the main losses are nearly independent of the output.

Combining now the I.H.P. at the engine with the E.H.P. on the car line, and making proper allowance for the power consumed in the lamps and on the stationary motor line, we have as the average efficiency of the power station, $\frac{\text{E.H.P.}}{\text{I.H.P.}} = 40{\cdot}7$ per cent. average throughout the day, and for the maximum efficiency $\frac{\text{E.H.P.}}{\text{I.H.P.}} = 65{\cdot}0$ per cent.

The light line in fig. 1 gives the variation of the efficiency throughout the day.

The coal burned during the day was 4.500 pounds of slack, which is at the rate of 7·3 pounds per I.H.P., hour, or nearly 16 pounds per E.H.P. hour. We have shown in these facts by far the greatest source of loss in electric traction, both here and elsewhere. It is worth while considering in some detail the nature and cause of this loss, in how far loss at this point is necessary, and what means can best be taken to lessen it. The key to the whole situation lies in the immensely irregular calls for power in a tramway system.

The cause of this irregularity is obvious; the annexed diagram (fig. 2), will give a feeble idea of its amount. It shows the variation of the current on the line as given by the five minute readings between the hours of ten and noon on one of the days of test. Comment is unnecessary. But even this does not represent the real amount, for as a matter of fact the current is never even approximately constant for more than a few seconds at a time, and varies from *nil* to 60 or 70 ampères in a way that nothing but a continuous record can show. As a result of this the mean output is, on a system of this size, less than 25 per cent. of the maximum, which may be called for and must be furnished at any moment. As the system becomes larger the ratio of mean to maximum output increases until for a large system it may amount to one-half. The value of this ratio on the Richmond (Va.) road, judging from Mr. Sprague's figures, rises to nearly this amount. The values will then range from ·20 for a small road with high grades to ·50 or ·60 for a large road (40 or 50 cars) in a level region. Grades evidently tend to diminish its value considerably, though their effect may be partially counteracted in a small road by tact in arranging the schedule.

To supply power to such a system an engine must be able to give the maximum power demanded on very short notice, and will be habitually worked at from a fifth to a half of its full horse-power. This affects the efficiency of the system in two very pernicious ways—first, by requiring the use of a disproportionately large engine with friction to match; and, second, by working that engine in a very uneconomical way.

As regards the first count, the friction of an engine is nearly independent of the load, quite as often decreasing under heavy load as increasing. It gradually increases with the speed, and slightly increases with increasing length of cut-off. As to the amount of friction it varies, of course, very widely, but in modern engines of good make it will generally be from 5 to 10 per cent. of the full normal output.

This means, then, that if such an engine be worked on the average at a quarter of its full power the loss from friction will be from 20 to 40 per cent. of the indicated horse-power, usually much nearer the latter figure than the former.

This is bad enough, but it is not the worst. When used under these circumstances an engine is, on the average, working under conditions of expansion very far from economical. The cut-off is very much too short for advantageous working. The best point of cut-off is probably given by Emery's formula :—

$$\frac{1}{r} = \frac{1}{1 + \frac{p}{22}}.$$

Where r is the ratio of expansion and p the absolute pressure in pounds per square inch. Even this point of cut-off is probably rather small for ordinary engines. Applying the above formula to the case of the engine tested in these experiments, the best point would appear to be between one-fourth and one-fifth stroke. On examining the indicator cards taken at or near the point of average output, the engine seems to be cutting off at between an eighth and a ninth of the stroke. There is, therefore, a disastrous amount of condensation, and the final result appears in the 7·3 pounds of coal per I.H.P. hour. A Corliss engine like the one in question should, if used under favourable conditions, give the I.H.P. hour for three pounds of coal or less, while under this erratically varying cut-off it requires more than twice that amount. It is very important, then, to avoid as far as possible these very wasteful conditions of working. The problem, then, is to work an engine on the average at its most economical point of cut-off, while retaining the power of responding to sudden, though brief, demands for several times the average horse-power. In the first place, these sudden demands are sometimes but for a second or two, generally for less than half a minute, and, whatever the engine used, a heavy flywheel would be of great service in smoothing the irregularities of the output and helping the engine through a sudden emergency. Second, the engine itself should have a very wide range of cut-off to enable one to make the average expansion the most economical one. In an engine which must be habitually used at one-fourth power, the steam should be made to follow for nearly full stroke if necessary, in order to bring the average point of cut-off to the right value. Any valve gear which cannot cut off beyond half stroke is decidedly objectionable, since it necessitates too large an engine and too great a ratio of expansion.

To avoid friction as well, the engine should be the smallest, competent to furnish the maximum power; hence it should take high pressure steam and have a high rotational velocity. As regards application of power, it should be as direct as possible, avoiding countershafts and the like. All these considerations point distinctly to the use of high pressure steam in a rather small high speed engine capable of cutting off up to three quarters stroke, driving a heavy flywheel, and belted direct to the dynamos. Such engines can be obtained and are capable of giving the I.H.P. hour on 3 to 4 pounds of coal. The day of low speeds and gigantic cylinders is fast passing by, and nowhere do they appear at less advantage than in work under extreme variations of load. An engine of the kind mentioned above would, under favourable conditions, have a coefficient of friction not exceeding 15 per cent. of the average I.H.P., and require less than 5 lbs. of coal per I.H.P. hour, even under the variable load necessary. It should then be able, when belted direct to the dynamo, to give the electrical horse-power hour for about 7 lbs. of coal. The load being less variable in a large power station, conditions of economy are more easily reached, and as nearly as can be calculated from Mr. Sprague's data in the power station of the Richmond Va., road, the E.H.P. hour required about 9 lbs. of coal.

As to the amount of power actually needed to operate a tramway line, the tests made here show almost exactly 2·5 E.H.P. per car. This is a smaller value than would be obtained from a larger and more heavily loaded line. The diagrams given by Mr. Sprague show that on the Richmond line the power required was approximately 4 to 5 E.H.P. per car. The Richmond cars, however, are larger and heavier than those here. In general, the power required seems to be 3—5 E.H.P. per car. To furnish this output the engine should be capable of producing about 10 to 15 I.H.P. per car, at full (say ¾) cut-off, the former figure for large and level systems, the latter for small systems and those with excessive grades. It should then be practicable to bring the efficiency of the power station, $\frac{\text{I.H.P.}}{\text{E.H.P.}}$, up to 70 per cent., in lieu of the 40 per cent. observed in these experiments. The efficiency of the Richmond system, which is operated by Armington and Sims engines running at 250 revolutions per minute must be somewhere near this figure, certainly as high as 60 per cent. This efficiency, it should be remembered, is not secured at any great expense, for such a plant is quite economical in first cost as well as in operation.

The next experiments were to determine the losses on the line. These were found from observations of the fall of potential between power station and cars, taken both on regular and special trips. The efficiency of the line is a constantly varying quantity, changing, of course, with the position and ohmic resistance of the motors. A general average along the line showed an efficiency of 90—95 per cent.

Attention was next turned to the speed and efficiency of the motors. The observations were confined to a single car, No. 106, which was a good average car in its general performance. As a preliminary the resistance of the motors and connections was measured with the switch in each successive step. These resistances measured cold were :—

Step.	R.	Step.	R.
1	10·76	5	2·83
2	6·98	6	2·83
3	6·98	7	2·17
4	5·44		

The resistance of an armature cold was 1·2 ohms, measured from brush to brush.

Two spaces each of $\frac{1}{10}$th mile were then measured off, one on a level, the other on a grade of 6·58 per cent. average. Experimental runs were then made with car No. 106, carrying 19 persons and instruments. The total weight of car and contents was 8,200 lbs. The runs were made in each case with a flying start; each step of the switch being separately tested.

The results of an experiment on the level were as follows:—

Step.	Miles per hour.	Volts.	Ampères.	E.H.P.
1	7·5	404	9·5	5·15
2	9·3	416	10·4	5·79
4	9·1	393	10·7	5·64
5	10·9	434	16·1	9·35
7	12·4	433	15·4	8·93

The somewhat anomalous result in step 4 is due to the very considerable drop in voltage.

From these experiments the efficiency of the motors may be deduced, and since the motors are geared down very nearly 12 times, the armature speed can also be obtained. In computing the electrical efficiency of the motors, allowance must, of course, be made for increase of ohmic resistance due to heating, for self-induction, hysteresis, &c. Following Mr. Sprague's own figures, I have allowed 10 per cent. increase in resistance by heating. It is my firm conviction that this, under favourable conditions, will more than cover the above losses. Nevertheless the loss due to hysteresis must be quite considerable. Computing this by Hopkinson's method for an approximate size of core, and an armature speed of 1,200 revolutions per minute, it appears that the energy spent in hysteresis may amount to somewhere nearly 500 watts. The loss of energy due to sparking may also rise frequently to a quite perceptible amount.

Computing then the electrical efficiencies under the various conditions, we have the following results:—

Step.	Armature. Speed.	E.H.P.	Motor E.H.P.	$\frac{C\,e}{C\,E}$ Per cent.
1	1,000	5·15	3·72	72·3
2	1,230	5·79	4·67	80·7
4	1,200	5·64	4·74	84·2
5	1,450	9·35	8·29	88·7
7	1,650	8·93	8·18	91·5

Unfortunately a car motor does not lend itself at all readily to brake tests, the conditions of such a test being widely different from those under which the motor works. We can, however, obtain an approximation to the commercial efficiency by computing as nearly as practicable the coefficient of friction on track, and then applying this to the data obtained on a known grade to estimate the work actually done.

Assuming, then, a loss of 10 per cent. in friction of motors and gearing, in accordance with Mr. Sprague's own estimate, and using the data above, the coefficient of friction appears to be two per cent.; in other words, 40 lbs. per ton. This is a high value, but, I think, justified by the condition of the track.

Substituting this constant in the formula used with the results of the grade test, we can obtain a close approximation to the commercial efficiency, and a check on the above estimate of 10 per cent. friction.

The grade tests were with the same car and load. The results were as follows:

Step.	Miles. per hour.	Volts.	Ampères.	E.H.P.
2	2·73	347	27·2	12·65
4	4·2	403	27·4	13·47
5	9·3	409	31·3	17·14
7	6·2	365	32·4	15·85

The general voltage here was rather low, produced in part by the location of the grade relative to the power station, and mainly to heavy demands for current during the test. It serves to emphasise what I have previously mentioned, the advantage of using compound wound dynamos on tramway work.

Computing now the electrical efficiency by means of the above data:

Step.	Armature speed.	E.H.P.	Motor E.H.P.	$\frac{C\,e}{C\,E}$ Per cent.
2	333	12·65	5·08	39·9
4	545	13·47	7·98	59·3
5	840	17·14	13·04	76·1
7	830	15·85	12·50	78·9

Step 1 was not tried on the hill on account of endangering the field coils. Notice for example that in case of step 2 there is 7·59 E.H.P. spent on internal work. No coil can stand such treatment for any length of time, and with this light it is quite easy to see why fields and armatures burn out. On a grade like this, nothing short of full power should ever be used.

Compute now the actual work done by the motors on this grade, using the above data and the friction coefficient previously found. We have then virtually the brake horse-power, and hence the commercial efficiency $\frac{\text{B.H.P.}}{\text{E.H.P.}}$

Step.	M.E.H.P. 10 per cent.	B.H.P.	$\frac{\text{B.H.P.}}{\text{E.H.P.}}$ Per cent.
2	4·56	4·67	36·9
4	7·19	7·65	56·9
5	11·74	11·80	67·6
7	11·35	11·61	73·2

The agreement between the second and third columns shows that the estimate of 10 per cent. for friction of motors and gears was substantially correct. A second approximation could, of course, be deduced. It appears, therefore, that the motors with their gears may reach an efficiency of over 80 per cent. on the level, or over 70 per cent. on a severe grade when used under favourable conditions. When used with the lower steps of the switch the resistance of the field coils is so high as to reduce the efficiency enormously. In other words, when the cars run slowly they do so at the expense of greatly diminished efficiency. Still, less power is used, and if the field coils are well insulated the lowest step of the switch sufficient to give the required speed will be the most economical one. On grades, however, the fifth or seventh step should be always used to avoid excessive heating. The very high ohmic resistance of these motors is a source of continual loss, as has been pointed out in detail by Mr. Snell (the *Electrician*, Vol. XXI., p. 522), and is the cause of unnecessarily great destruction of field coils. It may be possible to so insulate the coils as to withstand the roasting to which they are too often subjected, but this is a questionable way out of the difficulty.

From observations on the cars during regular trips, the average electrical efficiency in ordinary use appears to be about 75 per cent., and the commercial efficiency of motors and gearing 65 to 70 per cent.

We are now in a position to obtain the approximate efficiency of the entire system $\frac{\text{B.H.P.}}{\text{I.H.P.}}$.

The mean value for this line as at present worked is about 25 per cent. The chief cause of this low efficiency has been already pointed out. The figure will probably be considerably increased before long by the increasing use of stationary motors, which will raise the mean electrical output to something like the proper figure. As a system increases in size the efficiency will rise, and in a system as large as that at Richmond the total mean efficiency would appear from the data obtainable to be a little over 40 per cent. This may seem a low figure, but it should be remembered that traction work is probably the least favourable to high efficiency of any task to which an electric motor can be put.

Most of the losses incurred are unavoidable; engines will not run without friction, dynamos are not of ideal efficiency, line wire will have resistance, an electrical current will generate heat in motors and gears will grind and wear. Losses like these cannot be avoided or reduced below certain limits. These limits are not easy to set, but one can safely say that a total mean efficiency, $\frac{\text{B.H.P.}}{\text{I.H.P.}}$, of anything over 50 per cent. would be a very remarkable performance for a traction system in actual use.

I do not think that 60 per cent. is likely to be reached without very radical improvements. This applies of course to the direct supply systems. The storage battery requires a separate investigation. In that case the power stations can be worked to rather greater advantage than with direct supply, since the load can be made much more regular. There is no loss by line wire but there is a very serious loss in the accumulators themselves. The laboratory efficiencies of storage batteries rise to a most tempting amount, 80 per cent. and over, but the irregular discharge rate necessary in operating a tramway is even more disastrous to the efficiency of a storage battery than to the efficiency of an engine. With any accumulator now made, a mean efficiency of over 65 per cent. is doubtful under the conditions which exist in tramway work. There is great need of careful tests under something like working conditions, but so far as I am aware none have been published, at least none of any scientific definiteness. I may here remark that, with very few exceptions, the reports published on electrical traction work are models of how to avoid giving definite information.

Perhaps the most serious charge against the accumulator is its very great weight. It appears to require about 3,500 lbs. of battery to operate a car successfully, and this amount must be carried as well as the passengers. Of the total electrical output then, something like 25 per cent. is employed in dragging around this dead weight. But this is not at all. Sit down with a list of storage batteries and compute the weight required to furnish the car, say 10 E.H.P. The fact at once appears that if we undertake to supply from storage batteries the same amount of power we supply from a line, we shall need something like twice the above weight of storage battery. In short, the weight of battery is reduced by reducing the supply of power.

Nevertheless, the storage system is deserving of consideration. Each car is a unit, there are no conduits or overhead wires, there is lessened danger of breakdowns, and independence generally. If the storage battery comes to be of reasonable durability and weight, it will furnish an ideal solution of the tramway problem, particularly for city work, where overhead wires are a nuisance and conduits are troublesome.

Given a mean efficiency of 60 to 70 per cent. for the accumulators, it is easy to form a pretty clear idea of the total mean efficiency of the storage system. The power station will be somewhat more efficient than with direct supply, $\frac{\text{E.H.P.}}{\text{I.H.P.}}$ being perhaps 80 per cent.; the batteries will be of, say, 65 per cent. efficiency, and finally the motors will be about as before, giving a total efficiency of a little less than 40 per cent. In practice this is diminished by the fact that for the same service the storage system car would require from a fourth to a third more power on account of its constant load of battery. So far as efficiency is concerned, there seems to be little prospect of the storage system equalling direct supply, since the loss on the line is so small compared with that in the battery.

Probably the most effective rival of electricity is the cable traction system, and it is well to look into its efficiency a little. Facts are not particularly easy to get at. Some of the theoretical discussions of transmission by wire rope give a preposterously high efficiency. A valuable paper, however, in the Journal of the Association of Engineering Societies, September, 1888, gives some interesting and authentic figures as to efficiency, details of construction, and cost.

The St. Louis and Western cable road, having a cable in one piece 34,600 feet long, required 185 H.P. to drive the empty cable at the rate of eight miles an hour. Regular capacity of the road 40 cars (20 trains of grip and car). Under ordinary conditions of traffic 180 to 190 H.P. additional was required to operate these cars, 9–9·5 H.P. per train. Curves are numerous on the road.

The Fifth Street Road, Kansas City, operates 40,000 feet of cable. The conditions of working are better than at St. Louis, there being few curves. Twenty trains are operated, taking under usual conditions 280 I.H.P., 120 of which is required to drive the cables at the rate of 8 miles per hour, leaving 8 H.P. per train as the power required.

In these roads, then, 50 to 60 per cent. of the indicated horse-power seems to be applied to doing useful work.

It is instructive to compare this performance with that of the Richmond Electric Road, which operates single and double track, covering 8·8 miles of streets, and 40 cars aggregating almost exactly the same weight and seating capacity as the above 20 trains. The mean electrical output at the power station is per car 4·5 E.H.P. Making due allowance for loss in the power station, it appears that the total power required to operate the system is about the same as in the Kansas City cable line, and distinctly less than in the St. Louis cable. The curves and grades in Richmond are more severe than in the Kansas City line.

We may conclude then that in the case of good-sized systems the power required to operate is nearly the same with cables and electricity; the former having the advantage on short and easy lines, the latter on long and difficult ones. On smaller systems electricity has a decided advantage since the loss of power in the motors depends on their number, while the loss in dragging a cable is constant.

But there is another side to this comparison, the economic one. A cable road costs $50,000 to $75,000 per mile, owing to the large and complicated sub-structure. This does not include power stations or rolling stock. This cost is four or five times greater than for an electric overhead road, even under unfavourable conditions, and something like twice as great as for an electrical conduit system. This comparison supposes the electric road to be laid and wired in the most efficient and permanent way. Under ordinary circumstances the difference in first cost would be even greater. The difference in running expense is not so easy to estimate. Not far from the same amount of power is required, though it is probably procured at rather less expense of coal in the cable system. The number of *employés* cannot be widely different, the difference being of little moment. The cable conduit, however, requires decidedly more care than the electric line, supposing the latter to have been properly put up in the first place.

As to repairs, on an electric system using overhead wires, the line if properly put up and occasionally aligned should give very little trouble. The trolley of whatever description is subject to constant wear and must frequently be renewed or repaired, and the brushes rapidly wear out. On some lines the wear of brushes amounts to almost a set per week per car. There is great chance for improvement here. The field coils now and then burn out, in some cases frequently, and occasionally an armature is damaged. On a cable line the cable itself is a considerable item of expense. Its life may be from six to eighteen months, though occasionally only a few weeks; and the expense of renewal is considerable. The grips are subject to continual wear, the dies that form the jaws generally lasting only a week or ten days. The running gear along the line requires constant watchfulness and attention, and the minor repairs on this must be considerable. As regards the comparison of actual operating expenses it is almost impossible to get definite information. Both cables and electricity are distinctly cheaper than horses. Reports from the Chicago cable roads indicate expenses about 50 per cent. of the cost of operating by horses. From this the figure may rise to 75 per cent. Reports of anything like a definite kind from electric roads are scarce. Such scattered figures as can be collected tend to show that the operating expenses are about the same as for cables on systems of the same size. Details of operation vary so much from place to place that it would at present be unjustifiable to say more than this. The detailed reports from electric roads have for the most part been from very small ones. A recent one from the Davenport, Ia., road shows expenses 97 per cent. of those with horses the previous year, and net profit three times as great. This road operates only four regular cars. One or two small English roads report something of the same kind, slightly diminished expenditures and greatly increased receipts.

In closing it seems worth while to say a word about the use of electricity for ordinary railroad work. In elevated roads there can be little question about the matter; the smoke and dust of the locomotive are quite enough to condemn it, and as the consumption of coal is over 6 lbs. per horse-power hour, an electric system can push it hard in the matter of economy. In ordinary cases, however, there is no call for sacrificing economy for the sake of the characteristic advantages of an electric system. It is quite possible for a locomotive to give the horse-power hour on 4 lbs. of coal, a figure which can probably be reduced. This leaves no very large margin for the double transformation of an electric system. In fact, so long as we have to depend on the steam engine and dynamo for our supply of electricity, competition with the direct use of steam in locomotives will be hopeless. Even water power will not be of much avail, and the longer the line to be operated the less chance of success. If we could get electricity directly from heat in any economical way the problem of power would be solved.

Finally, with regard to electric traction systems, most lines of road are not laid and wired with sufficient care, and most of the minor difficulties in operating come from this fact. A line with track hastily and imperfectly laid, with wiring carelessly put up on rickety poles, and imperfectly aligned, will surely encounter plenty of small but exasperating difficulties and bills for repairs that will be anything but pleasant. A vigilant system of car and line inspection will avoid most of the little accidents that interrupt traffic and will more than pay for itself in lessened repairs. With a carefully constructed line, and a properly designed power plant, electric traction becomes thoroughly reliable and remarkably economical. Without these it may be very uncertain in its operation, and while it will nearly always pay, the size of the dividends will not be pleasant to contemplate. If much power is to be used for stationary motors, it is better, and in the long run cheaper to divide the plant than to rely entirely upon a single engine.

I cannot close this paper without expressing my obligations to Mr. Hawter, superintendent of the road, who has facilitated this investigation in every way possible, and to Messrs. F. W. Brady and W. J. Lutz, post-graduate students in this university, for most efficient aid throughout the tests.

ON MODERN VIEWS WITH RESPECT TO THE NATURE OF ELECTRIC CURRENTS.[*]

By PROF. H. A. ROWLAND.

As, a short time since, I stood in a library of physical books and glanced around me at the works of the great masters in that subject, my mind wandered back to the time when the apparatus for a complete course of lectures on the subject of electricity consisted of a piece of amber and a few light bodies to be attracted by it. From that time until now, when we stand in a magnificent laboratory with elaborate and costly apparatus in great part devoted to its study, how greatly has the world changed, and how our science of electricity has expanded both in theory and practice until, in the one case, it threatens to include within itself nearly the whole of physics, and in the other to make this the age of electricity.

Were I to trace the history of the views of physicists with respect to electric currents it would include the whole history of electricity. The date when the conception of an electric current was possible was that when Stephen Gray, about 170 years ago, first divided bodies into conductors and non-conductors, and showed that the first possessed the property of transmitting electric attractions to a distance. But it was only when the Leyden jar was discovered that the idea of a current became very definite. The notion that electricity was a subtle fluid which could flow along metal wires as water flows along a tube, was then prevalent, and, indeed, remains in force to-day among all except the leaders in scientific thought. It is not my intention to depreciate this notion, which has served and still serves a very important purpose in science. But, for many years, it has been recognised that it includes only a very small portion of the truth, and that the mechanism by which energy is transmitted from one point of space to another by means of an electric current is a very complicated one.

Here, for instance, on the table before me are two rubber tubes filled with water, in one of which the water is in motion and the other at rest. It is impossible by any means now known to us to find out, without moving the tubes, which one has the current of water flowing in it and which has the water at rest. Again, I have here two wires, alike in all respects, except that one has a current of electricity flowing in it and the other has not. But in this case I have only to bring a magnetic needle near the two to find out in which one the current is flowing. On our ordinary senses the passage of the current has little effect; the air around it does not turn green or the wire change in appearance. But we have only to change our medium from air to one containing magnetic particles to perceive the commotion which the presence of a current may cause. Thus this other wire passes through the air near a large number of small suspended magnets, and, as I pass the current through it, every magnet is affected and tends to turn at right angles to the wire and even to move toward it and wrap itself around it. If we suppose the number of these magnets to become very great and their size small, or if we imagine a medium, every atom of which is a magnet, we see that no wire carrying a current of electricity can pass through it without creating the greatest commotion. Possibly this is a feeble picture of what takes place in a mass of iron near an electric current.

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[*] A lecture given at the College of the City of New York, May 22nd, 1889, before the American Institute of Electrical Engineers.

Again, coil the wire around a piece of glass, or, indeed, almost any transparent substance, and pass a strong current through the wire. With our naked eye alone we see no effect whatever, as the glass is apparently unaltered by the presence of the current, but, examined in the proper way by means of polarised light, we see that the structure of the glass has been altered throughout in a manner which can only be explained by the rotation of something within the glass many millions of times every second.

Once more, bring a wire in which no current exists nearer and nearer to the one carrying the current, and we shall find that its motion in such a neighbourhood causes, or tends to cause, an electric current in it. Or, if we move a large solid mass of metal in the neghbourhood of such a current we find a peculiar resistance unfelt before, and if we force it into motion, we shall perceive that it becomes warmer and warmer, as if there was great friction in moving the metal through space.

Thus, by these tests, we find that the region around an electric current has very peculiar properties which it did not have before, and which, although stronger in the neighbourhood of the current, still extend to indefinite distances in all directions, becoming weaker as the distances increase.

How great, then, the difference between a current of water and a current of electricity. The action of the former is confined to the interior of the tube, while that of the latter extends to great distances on all sides, the whole of space being agitated by the formation of an electric current in any part. To show this agitation, I have here two large frames with coils of wire around them. They hang face to face about 6 feet apart. Through one I discharge this Leyden jar, and immediately you see a spark at a break in the wire of the other coil, and yet there is no apparent connection between the two. I can carry the coils 50 feet or more apart, and yet, by suitable means, I can observe the disturbances due to the current in the first coil.

FIG. 1.—PENETRATION OF ALTERNATING CURRENT IN A ROUND SOLID CONDUCTOR.

The question is forced upon us as to how this action takes place. How is it possible to transmit so much power to such a distance across apparently unoccupied space? According to our modern theories of physics there must be some medium engaged in this transmission. We know that it is not the air, because the same effects take place in a vacuum, and, therefore, we must fall back on that medium which transmits light, and which we have named the ether. That medium which is supposed to extend unaltered throughout the whole of space, whose existence is very certain, but whose properties we have yet but vaguely conceived.

I cannot, in the course of one short hour, give even an idea of the process by which the minds of physicists have been led to this conclusion, or the means by which we have finally completely identified the ether which transmits light with the medium which transmits electrical and magnetic disturbances. The great genius who first identified the two is Maxwell, whose electro-magnetic theory of light is the centre around which much scientific thought is to-day revolving, and which we regard as one of the greatest steps by which we advance nearer to the understanding of matter and its laws. It is this great discovery of Maxwell which allows me, at the present time, to attempt to explain to you the wonderful events which happen everywhere in space when one establishes an electric current in any other portion.

In the first place, we discover that the disturbance does not take place in all portions of space at once, but proceeds outwards from the centre of the disturbance with a velocity exactly equal to the velocity of light. So that, when I touch these wires together so as to complete the circuit of yonder battery, I start a wave of etherial disturbance which passes outward with a velocity of 185,000 miles per second, thus reaching the sun in about eight minutes, and continuing to pass outwards for ever, or until it reaches the bounds of the universe. And yet none of our senses inform us of what has taken place unless we sharpen them by the use of suitable instruments. Thus, in the case of these two coils of wire, suspended near each other, which we have already used, when the wave from the primary disturbance reaches the second coil, we perceive the disturbance by means of the spark formed at the break in the coil. Should I move the coils further apart, the spark in the second coil would be somewhat delayed, but the distance of 185,000 miles would be necessary before this delay could amount to as much as one second. Hence the effects we observe on the earth take place so nearly instantaneously that the interval of time is very difficult to measure, amounting, in the present case, to only $\frac{1}{185000000}$th of a second.

FIG. 2.—PENETRATION OF ALTERNATING CURRENT IN A ROUND SOLID CONDUCTOR.

It is impossible for me to prove the existence of this interval but I can at least show you that waves have something to do with the action here observed. For instance, I have here two tuning forks mounted on sounding boxes and tuned to exact unison. I sound one and then stop its vibrations with my hand; instantly you hear that the other is in vibration, caused by the waves of sound in the air between the two. When, however, I destroy the unison by fixing this piece of wax on one of the forks the action ceases.

Now, this combination of a coil of wire and a Leyden jar form a vibrating system for electricity, and its time of vibration is about 10,000,000 times a second. This second system is the same as the first, and therefore its time of vibration is the same. You see how well the experiment works now because the two are in unison. But let me take away this second Leyden jar, thus destroying the unison, and you see that the sparks instantly cease. Replacing it, the sparks reappear. Adding another on one side and they disappear again, only to reappear when the system is made symmetrical by placing two on each side.

This experiment and that of the tuning forks have an exact analogy to one another. In each we have two vibrating systems connected by a medium capable of transmitting vibrations, and they both come under the head of what we know as sympathetic vibrations. In the one case, we have two mechanical tuning forks connected by the air; in the other, two pieces of apparatus, which we might call electrical tuning forks, connected by the luminiferous ether. The vibrations in one case can be seen by the eye or heard by the ear, but in the other case they can only be perceived when we destroy them by making them produce a spark. The fact that we are able to increase the effect by proper tuning demonstrates that vibrations are concerned in the phenomenon. This can, however, be separately demonstrated by examining the spark by means of a revolving mirror, when we find that it is made up of many successive sparks corresponding to the successive backward and forward movements of the current.

The fact of the oscillatory character of the Leyden jar discharge was first demonstrated by our own countryman, Henry, in 1832, but he pursued the subject only a short distance, and it remained for Sir William Thomson to give the mathematical theory and prove the laws according to which the phenomenon takes place.

Thus, in the case of a charged Leyden jar, whose inner and outer coatings have been suddenly joined by a wire, the electricity flows back and forth along the wire until all the energy originally stored up in the jar has expended itself in heating the wire or the air where the spark takes place, and in generating waves of disturbance in the ether which move outward into space with the velocity of light. These etherial waves we have demonstrated by letting them fall on this coil of wire, and causing the electrical disturbance to manifest itself by electric sparks.

I have here another more powerful arrangement for producing electro-magnetic waves of very long wave length, each one being about 500 miles long. It consists of a coil within which is a bundle of iron wires. On passing a powerful alternating current through the coil, the iron wires are rapidly magnetised and demagnetised, and send forth into space a system of electro-magnetic waves at the rate of 360 in a second.

Here, also, I have another piece of apparatus for sending out the same kind of electro-magnetic waves, and on applying a match, we start it also into action.* But the last apparatus is tuned to so high a pitch that the waves are only $\frac{1}{50000}$th inch long, and 55,000,000,000,000 are given out in one second. These short waves are known by the name of light and radiant heat, though the name radiation is more exact. Placing any body near the lamp so that the radiation can fall on it, we observe that when the body absorbs the rays, it is heated by them, the well-known property of so-called radiant heat and light. Is it not possible for us to get some substance to absorb the long waves of disturbance, and so obtain a heating effect? I have here such a substance in the shape of a sheet of copper, which I fasten on the face of a thermopile, and I hold it where these waves are the strongest. As I have anticipated, great heat is generated by their absorption, and soon the plate of copper becomes very warm, as we see by this thermometer, by feeling of it with the hand, or even by the steam from water thrown upon it. In this experiment the copper has not touched the coil or the iron wire core, although if it did they are very much cooler than itself. The heat has been produced by the absorption of the waves, in the same way as a blackened body absorbs the rays of shorter wave length from the lamp, and, in both cases, heat is the result.

But in this experiment, as in the first one, the wave-like nature of the disturbance has not been proved experimentally. We have caused electric sparks, and have heated the copper plate across an interval of space, but have not in either of these cases proved experimentally the progressive nature of the disturbance.

A ready means of experimenting on the waves, obtaining their wave length and showing their interferences, has hitherto been wanting. This deficiency has been recently overcome by Prof. Hertz, of Carlsruhe, who has made a study of the action of the coil, and has shown us how to use it for experiments on the etherial waves whose existence had before been made certain by the mathematics of Maxwell.

I scarcely know how to present this subject to a non-technical audience and make it clear how a coil of wire with a break in it can be used to measure the velocity and wave length of etherial waves. However, I can but try. If the waves moved very slowly, we could readily measure the time the first coil took to affect the second, and show that this time was longer as the distance was greater. But it is absolutely inappreciable by any of our instruments, and another method must be found. To obtain the wave length, Prof. Hertz used several methods, but that by the formation of stationary waves is the most easily grasped. Mr. Ames holds in his hand one end of a spiral spring, which makes a very heavy and flexible rope. As he sends a wave down it, you see that it is reflected at the further end, and returns again to his hand. If, however, he send a succession of waves down the rope, the reflected waves interfere with the direct ones, and divide the rope into a succession of nodes and loops, which you now observe. So a series of sound waves, striking on a wall, form a system of stationary waves in front of the wall. Indeed, we can use any waves for this purpose, even etherial waves. With this in view Prof. Hertz established his apparatus in front of a reflecting wall, and observed the nodes and loops by the sparks produced in a ring of wire, somewhat resembling the coil I have been using on the present occasion, but much smaller. It is impossible for me to repeat this experiment before you, as it is a very delicate one, and the sparks produced are almost microscopic. Indeed, I should have to erect an entirely different apparatus, as the waves from the one before me are nearly ¼ mile long, the time of vibration of the system being very great, that is, $\frac{1}{10000000}$th of a second. To produce shorter waves, we must use apparatus tuned, as it were, to a higher pitch, in which the same principle is, however, employed, but the etherial waves are shorter, and thus several stationary waves can be contained in one room.

The testing coil is then moved to different portions of the room, and the nodes are indicated by the disappearance of the sparks, and the loops by the greater brightness of them. The presence of stationary waves is thus proved, and their half waves length found from the distance from node to node, for stationary waves can always be considered as produced by the interference of two progressive waves advancing in opposite directions.

However interesting a further description of Prof. Hertz's experiments may be, we have gone as far in that direction as our subject carries us, for we have demonstrated that the production of a current in a wire is accompanied by a disturbance in the surrounding space; and although I have not experimentally demonstrated the etherial waves, yet I have proved the existence of electric oscillations in the coils of wire and the ether surrounding it.

Our mathematics has demonstrated, and experiments like those of Prof. Hertz have confirmed the demonstration, that the wave disturbance in the ether is an actual fact.

The closing of a battery circuit, then, and the establishment of a current of electricity in a wire, is a very different process from the formation of a current of water in a pipe, though, after the first shock, the laws of the flow of the two are very much alike. But even then the medium around the current of electricity has very strange properties, showing that it is accompanied by a disturbance throughout space. The wire is but the core of the disturbance, which latter extends indefinitely in all directions.

One of the strangest things about it is that we can calculate with perfect exactness the velocity of the wave propagation, and the amount of the disturbance at every point and at any instant of time; but as yet we cannot conceive of the details of the mechanism which is concerned in the propagation of an electric current. In this respect our subject resembles all other branches of physics in the partial knowledge we have of it. We know that light is the undulation of the luminiferous ether, and yet the constitution of the latter is unknown. We know that the atoms of matter can vibrate with purer tones than the most perfect piano, and yet we cannot even conceive of their constitution. We know that the sun attracts the planets with a force whose law is known, and yet we fail to picture to ourselves the process by which it takes our earth within its grasp at the distance of many millions of miles, and prevents it from departing for ever from its life-giving rays. Science is full of this half knowledge, and the proper attitude of the mind is one of resignation toward that which it is impossible for us to know at present, and of earnest striving to help in the advance of our science, which shall finally allow us to answer all these questions.

The electric current is an unsolved mystery, but we have made a very great advance in understanding it when we know that we must look outside of the wire at the disturbance in the medium before we can understand it—a view which Faraday dimly held 50 years ago, which was given in detail in the great work of Maxwell, published 16 years since, and has been the guide to most of the work done in electricity for a very long time—a view which has wrought the greatest changes in the idea which we have conceived with respect to all electrical phenomena.

So far we have considered the case of alternating electric current in a wire connecting the inner and outer coatings of a Leyden jar. The invention of the telephone, by which sound is carried from one point to another by means of electrical waves, has forced into prominence the subject of these waves. Furthermore, the use of alternating currents for electric lighting brings into play the same phenomenon. Here, again, the difference between a current of water and a current of electricity is very marked. A sound wave, traversing the water in the tube, produces a to and fro current of water at any given point. So, in the electrical vibration along a wire, the electricity moves to and fro along it in a manner somewhat similar to the water, but with this difference: The disturbance from the water motion is confined to the tube, and the oscillation of the water is greatest in the centre of the tube, while, in the case of the electric current, the ether around the wire is disturbed, and the oscillation of the current is greatest at the surface of the wire and least in its centre. The oscillations in the water take place in the tube without reference to the matter outside the tube, whereas the electric oscillations in the wire are entirely dependent on the surrounding space, and the velocity of the propagation is nearly independent of the nature of the wire, provided only that it is a good conductor.

We have then in the case of electrical waves along a wire a disturbance outside the wire, and a current within it, and the equations of Maxwell allow us to calculate these with perfect accuracy and give all the laws with respect to them.

We thus find that the velocity of propagation of the waves along a wire, hung far away from other bodies and made of good conducting material, is that of light, or 185,000 miles per second, but when it is hung near any conducting matter, like the earth, or enclosed in a cable and sunk into the sea, the velocity becomes much less. When hung in space, away from other bodies, it forms, as it were, the core of a system of waves in the ether, the amplitude of the disturbance becoming less and less as we move away from the wire. But the most curious fact is that the electric current penetrates only a short distance into the wire, being mostly confined to the surface, especially where the number of oscillations per second is very great.

The electrical waves at the surface of a conductor are thus, in some respects, very similar to the waves on the surface of water. The greatest motion in the latter case is at the surface, while it diminishes as we pass downward and soon becomes inappreciable. Furthermore, the depth to which the disturbance penetrates into the water increases with increase of the length of the wave, being confined to very near the surface for very short waves. So the disturbance in the copper penetrates deeper as the waves and the time of oscillation are longer; and the disturbance is more nearly confined to the surface as the waves become shorter. I have recently made the complete calculation with respect to these waves, and have drawn some diagrams to illustrate the penetration of the alternating current into metal cylinders. The right-hand curve, fig. 1, represents the current at different depths in a copper cylinder 45 cm. diameter, or an iron one 14¼ cm. diameter, traversed by an alternating current with 200 reversals per second. That and the middle curve show us the current at two different instants of time, and show us how the phase changes as we pass downward into the cylinder. By reference to the middle curve we see that it may be even in the opposite direction in the centre of the cylinder from which it is at the surface. The third figure gives us the amplitude of the current oscillations at different depths, irrespective of the phase, and it shows us that the current at the centre is only about 10 per cent. of that at the surface in this case. The second diagram, fig. 2, shows us the distribution in the same cylinders when the number of reversals of the current is increased to 1,800 per second. Here we see that the disturbance is almost entirely confined to the surface, for at a depth of only 7 mm., the disturbance almost entirely vanishes.

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* The lecturer here lit a gas flame.

There are many practical applications of these theoretical results for electric currents. The most obvious one is to the case of conductors for the alternating currents used in producing the electric light. We find that when these are larger than about half an inch diameter they should be replaced by a number of conductors less than half an inch diameter, or by strips about quarter of an inch thick, and of any convenient width. But this is a matter to be attended to by the electric light companies.

Professor Oliver J. Lodge has recently, in the B.A., drawn attention to another application of these results—that is, to lightning rods. Almost since the time of Franklin, there have been those who advocated the making of lightning rods hollow in order to increase the surface for a given amount of copper. We now know that these persons had no reason for their belief, as they simply drew the inference from the fact that electricity at best is on the surface. Neither were the advocates of the solid rods quite correct, for they reasoned from the fact that electricity in a state of steady flow occupies the whole area of the conductor equally. The true theory, we now know, indicates that neither party was entirely correct, and that the surface is a very important factor in the case of a current of electricity so sudden as that from a lightning discharge. But increase of surface can best be obtained by multiplying the number of conductors, rather than making them flat or hollow, and, at the same time, Maxwell's principle of enclosing the building within a cage can be carried out. Theory indicates that the current penetrates only one-tenth the distance into iron that it does into copper. As the iron has seven times the resistance of copper, we should need 70 times the surface of iron that we should of copper. Hence I prefer copper wire about a quarter of an inch diameter, and nailed directly to the house without insulators, and passing down the four corners around the eaves and over the roof, for giving protection from lightning in all cases where a metal roof and metal down spouts do not accomplish the same purpose.

Whether the discharge of lightning is oscillatory or not does not enter into the question, provided it is only sufficiently sudden. I have recently solved the mathematical problem of the electric oscillations along a perfectly conducting wire joining two infinite and perfectly conducting planes parallel to each other, and find that there is no definite time of oscillation, but that the system is capable of vibrating in any time in which it is originally started. The case of lightning between a cloud of limited extent and the earth along a path through the air of great resistance is a very different problem. Both the cloud and the path of the electricity are poor conductors, which tends to lengthen the time. If I were called on to estimate as nearly as possible what took place in a flash of lightning, I would say that I did not believe that the discharge was always oscillating, but more often consisted of one or more streams of electricity at intervals of a small fraction of a second, each one continuing for not less than $\frac{1}{100000}$th second. An oscillating current with 100,000 reversals per second would penetrate about $\frac{1}{80}$th inch into copper and $\frac{1}{800}$th inch into iron. The depth for copper would constitute a considerable proportion of a wire ¼ inch diameter, and, as there are other considerations to be taken into account, I believe it is scarcely worth while making tubes, or flat strips, for such small sizes.

It is almost impossible to draw proper conclusions from experiments on this subject in the laboratory, such as those of Prof. Oliver J. Lodge. The time of oscillation of the current in most pieces of laboratory apparatus is so very small, being often the $\frac{1}{1000000000}$th of a second, that entirely wrong inferences may be drawn from them. As the size of the apparatus increases the time or oscillation increases in the same proportion, and changes the whole aspect of the case. I have given $\frac{1}{100000}$th of a second as the shortest time a lightning flash could probably occupy. I strongly suspect it is often much greater, and thus departs even further from the laboratory experiments of Prof. Lodge, who has, however, done very much toward drawing attention to this matter and showing the importance of surface in this case. All shapes of the rod with equal surface are not, however, equally efficient. Thus, the inside surface of a tube does not count at all. Neither do the corrugations on a rod count for the full value of the surface they expose, for the current is not distributed uniformly over the surface; but I have recently proved that rapidly alternating currents are distributed over the surface of very good conductors in the same manner as electricity at rest would be distributed over them, so that the exterior angles and corners possess much more than their share of the current, and corrugations on the wire concentrate the current on the outer angles and diminish it in the hollows. Even a flat strip has more current on the edges than in the centre.

For these reasons, shape, as well as extent of surface, must be taken into account, and strips have not always an advantage over wires for quick discharges.

The fact that the lightning rod is not melted on being struck by lightning is not now considered as any proof that it has done its work properly. It must, as it were, seize upon the discharge, and offer it an easier passage to the earth than any other. Such sudden currents of electricity we have seen to obey very different laws from continuous ones, and their tendency to stick to a conductor and not fly off to other objects, depends not only on having them of small resistance, but also on having what we call the self-induction as small as possible. This latter can be diminished by having the lightning rod spread sideways as much as possible, either by rolling it into strips, or better, by making a network of rods over the roof with several connections to the earth at the corners, as I have before described.

Thus we see that the theory of lightning rods, which appeared so simple in the time of Franklin, is to-day a very complicated one and requires for its solution a very complete knowledge of the dynamics of electric currents. In the light of our present knowledge the frequent failure of the old system of rods is no mystery, for I doubt if there are a hundred buildings in the country properly protected from lightning. With our modern advances, perfect protection might be guaranteed in all cases, if expense were no object.

So much for the rod itself, and now let us turn to other portions of the electrical system, for we have seen that, in any case, the conductor is only the core of a disturbance which extends to great distances on all sides. Were the clouds, the earth, and the streak of heated air called the lightning flash all perfect conductors we could calculate the entire disturbance. It might then consist of a series of stationary waves between the two planes, extending indefinitely on all sides, but with gradually decreasing amplitude as we pass away from the centre. The oscillation, once set up, would go on for ever, as there would be no poor conductors to damp them. But when the clouds and the path of the lightning both have very great resistance, the energy is very soon converted into heat and the oscillations destroyed. I have given it as my opinion that this is generally the case, and that the oscillations seldom take place, but I may be wrong, as there is little to guide me except guess work. If they take place, however, we have a ready explanation of what is sometimes called a back stroke of lightning. That is, a man at the other end of the cloud, a mile or more distant from the lightning stroke, sometimes receives a shock, or a new lightning flash may form at that point and kill him. This may be caused, according to our present theory, by the arrival of the waves of electrical disturbance which might themselves cause a slight shock or even overturn the equilibrium then existing and cause a new electric discharge.

We have now considered the case of oscillations of electricity in a few cases, and can turn to that of steady currents. The closing of an electric current sends etherial waves throughout space, but that after the first shock the current flows steadily without producing any more waves. However, the properties of the space around the wire have been permanently altered, as we have already seen. Let us now study these properties more in detail. I have before me a wire in which I can produce a powerful current of electricity, and we have seen that the space around it has been so altered that a delicately suspended magnetic needle cannot remain quiet in all positions, but stretches itself at right angles to the wire, the north pole tending to revolve around it in one direction and the south pole in the other. This is a very old experiment, but we now regard it as evidence that the properties of the space around the wire have been altered rather than that the wire acts on the magnet from a distance.

Put, now, a plate of glass around the wire, the latter being vertical and the former with its plane horizontal, and pass a powerful current through the wire. On now sprinkling iron filings on the plate they arrange themselves in circles around the wire and thus point out to us the celebrated lines of magnetic force of Faraday. Using two wires with currents in the same direction we get these other curves, and, testing the forces acting on the wire, we find that they are trying to move toward each other.

Again, pass the currents in the opposite directions and we get these other curves and the currents repel each other. If we assume that the lines of force are like rubber bands which tend to shorten in the direction of their length and repel each other sideways, Faraday and Maxwell have shown that all magnetic attraction and repulsions are explained. The property which the presence of the electric current has conferred on the luminiferous ether is then one by which it tends to shorten in one direction and spread out in the other two directions.

We have thus done away with action at a distance, and have accounted for magnetic attraction by a change in the intervening medium as Faraday partly did almost fifty years ago. For this change in the surrounding medium is as much a part of the electric current as anything that goes on within the wire.

To illustrate this tension along the lines of force, I have constructed this model, which represents the section of a coil of wire with a bar of iron within it. The rubber bands represent the lines of force which pass around the coil and through the iron bar, as they have an easier passage through the iron than the air. As we draw the bar down and let it go, you see that it is drawn upward and oscillates around its position of equilibrium until friction brings it to rest. Here, again, I have a coil of wire with an iron bar within it with one end resting on the floor. As we pass the current and the lines of magnetic force form around the coil and pass through the iron, it is lifted upwards, although it weighs 24 pounds, and oscillates around its position of equilibrium exactly the same as though it were sustained by rubber bands as in the model. The rubber bands in this case are invisible to our eye, but our mental vision pictures them to us as lines of magnetic force in the luminiferous ether drawing the bar upward by their contractile force. This contractile force is no small quantity, as it may amount, in some cases, to one or even two hundred pounds to the square inch, and thus rivals the greatest pressure which we use in our steam engines.

Thus the luminiferous ether is, to-day, a much more important factor in science than the air we breathe. We are constantly surrounded by the two, and the presence of the air is manifest to us all; we feel it, we hear by its aid, and we even see it, under favourable circumstances, and the velocity of its motion, as well as the amount of moisture it carries, is a constant topic of conversation with mankind at large. The luminiferous ether, on the other hand, eludes all our senses, and it is only with imagination, the eye of the mind, that its presence can be perceived. By its aid in conveying the vibrations we call light, we are enabled to see the world around us, and by its other motions which cause magnetism, the mariner steers his ship through the darkest night when the heavenly bodies are hid from view. When we speak in a telephone, the vibrations of the voice are carried forward to the distant point by waves in the luminiferous ether, there again to be resolved into the sound waves of the air. When we use the electric light to illuminate our streets, it is the luminiferous ether which conveys the energy along the wires, as well as transmits it to our eye after it has assumed the form of light. We step upon an electric street car and feel it driven forward with the power of many horses, and again it is the luminiferous ether, whose immense force we have brought under our control and made to serve our purpose. No longer a feeble uncertain sort of medium, but a mighty power, extending throughout all space, and binding the whole universe together, so that it becomes a living unit in which no one portion can be changed without ultimately involving every other portion.

To this, ladies and gentlemen, we have been led by the study of electrical phenomena, and the ideas which I have set forth constitute the most modern views held by physicists with respect to electric currents.

NEW PATENTS—1889.

10263. "Transmitting signals to or from a locomotive engine by the aid of electricity." J. Gardner and T. R. Sowerbutts. Dated June 24.

10295. "Improvements in telegraphy." W. P. Thompson. (Communicated by C. G. Burke, United States.) Dated June 25. (*Complete.*)

10412. "Improvements in electric railway cars, and in underground conductors and appliances for the same." J. J. Butcher. Dated June 27.

10440. "Improvements in holders for incandescent electric lamps." H. Bayley. Dated June 27.

10461. "Improvements in electrical signalling apparatus." H. Brocklehurst and H. Constien. Dated June 27.

10517. "Improvements in elements for voltaic batteries." E. Frankland, N. Story-Maskelyne, A. H. Hough, and D. G. Fitz-Gerald. Dated June 28.

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1888.

5811. "Improvements in and connected with the generation and distribution of electrical power chiefly by alternating currents." R. E. B. Crompton and J. Swinburne. Dated April 19. 8d. In distribution of electrical power it is often necessary to couple two or more alternating current machines in parallel. When two or more alternating current machines are coupled in parallel there is often a tendency for them to get out of step. This causes waste of power in the armatures, and may even destroy them by undue heating. To avoid such mischances the inventors use what they call an induction coupler. If two machines are to be run in parallel on a circuit, one terminal of each is connected directly to one terminal of the circuit, and the other terminals of the dynamos are connected with the other terminal of the circuit through some turns round a soft iron core, such as used in transformers. The coils are so arranged that when the machines supply equal power to the external circuit the turns on the core neutralise each other so that the core is not magnetised; but if the machines begin to get out of step the induction coupler has the effect of inserting self-induction in the circuit including both armatures, so that they tend to come into step again. 6 claims.

7408. "Improvements in or relating to electrical fuses for firing the charge of blast holes and the like." A. J. Boult. (A communication from G. Manet and C. Manet, of Paris.) Dated May 18. 6d. Claim:—The construction of a fuse or detonator containing a platinum or other suitable wire in electrical connection with the line wires, substantially as specified.

8525. "Improvements in electric trembling bells." F. L. Rawson and P. Jolin. Dated June 11. 8d. Relates to improvements in electric trembling bells whereby they are rendered extremely simple in construction and very compact in appearance, and consists in constructing the base plate, single or double magnet core with cheeks, and pillar for carrying dome in one piece, conveniently in soft and annealed cast iron. 5 claims.

9082. "Improvements in electric arc lamps." W. R. Mortimer and J. Holloway. Dated June 20. 8d. Claims:—1. In combination with the tubular core and solenoid of an arc lamp, a lever pivotted to the core and having at one end a device for clamping the carbon holder passing through the core, while at the other end the lever is connected to an adjustable spring, so that when the core is raised by the action of the solenoid when excited by a current of a certain strength, the lever is caused by the spring to clamp the carbon holder and thereby raise it with the core, while when the core descends in consequence of the weakening of the solenoid current, the lever releases the carbon holder so as to allow it to descend, substantially as described. 2. In combination with the carbon holder of a lamp, a clamping device for the carbon consisting of two discs connected by screws and carrying between them a split socket for containing the carbon, such sockets having a spherical outer surface fitting spherical recesses in the discs, so that the socket can be both adjusted in position in the discs and be made by these to grip the carbon, substantially as described. 3. In an electric arc lamp, the combination of a solenoid or solenoids, tubular core with clamping device, and upper carbon holder with spherical clamping device for the carbon, arranged and operating substantially as described.

9672. "Improvements in dynamo-electric machines and electro motors." G. P. Lowrey, G. F. Seward, and T. L. Willson. Dated July 3. 11d. Relates more especially to machines of the Gramme type, and the improvements are embodied in the special construction of the armature, and in the relation of the brushes therewith, also in the special form of the field magnets and frame of the machine, in the details of the brush holders, in the driving connection between the armature and its shaft, and in several minor features detailed. The invention relates to that principle of construction in which the armature, instead of being wire-wound, as usual, is constructed of segmental copper bars arranged in two circles, one inside and one outside the iron core, and connected at the ends in spiral order, forming a continuous spiral of copper segments around the iron core, the segments being of course insulated by interposed strips of insulation. 11 claims.

9910. "Improvements in and relating to continuous current dynamo-electric machines." Gisbert Kapp. Dated July 7. 8d. Claims:—1. The improved drum armature constructed and arranged substantially as described and as illustrated by the drawings. 2. In flat iron or disc armature cores constructed of band iron, the arrangement at intervals of wider bands of metal or fibre having certain portions removed so as to leave projecting driving horns for the purpose of securely holding the copper winding, substantially as described and as illustrated by the drawings. 3. In continuous current dynamo-electric machines the construction and arrangement of the driving horns in such a manner that the horns in one set, row, or circle are intermediate to the horns in the neighbouring set, row, or circle, for the purpose of securing greater evenness in the distribution of the winding, substantially as described and as illustrated by the drawings. 4. In continuous current dynamo-electric machines the conductors, *s*, constructed of metallic plates, cables, or wires, arranged side by side upon a supporting sleeve and forming two circular rows for connection with the conductors on the armature, substantially as described and as illustrated by the drawings.

10092. "Improvements in the means or apparatus for supplying electricity to tramcars or other vehicles." A. L. Lineff. Dated July 11. 11d. A characteristic feature of the invention is that a magnet on the car or vehicle, as this travels, keeps attracting or drawing up fresh portions of an iron cable, and thus puts the conductor proper in electrical communication with one or two sections of an upper or surface rail, from which the current can be collected in the usual manner for driving the vehicle. 6 claims.

10654. "Improvements in electric arc lamps." W. R. Mortimer and J. Holloway. Dated July 23. 8d. Relates to improvements in the invention described in provisional specification of the 20th June, 1888, No. 9,082. 3 claims.

10782. "An electric meter." H. W. Miller. Dated July 25. 8d. Claim:—An electric meter consisting of a cylinder or of a number of conducting wires or strips fixed parallel to an axis around which conducting wires are coiled, connections whereby an electrical current is transmitted longitudinally along the cylinder or the equivalent wires or strips and a current is transmitted circularly through the coils, and a counter geared to the axis, arranged and operating substantially as described.

10887. (Under International Convention.) "Improvements in electric cartridges and primers." S. A. Day. Dated July 27. 11d. Relates to cartridges for electric guns and to electric primers or caps or exploders applicable to cartridge shells in order to convert them into electric cartridges. 9 claims.

11544. "Improvements in electrical coin freed machines." J. G. Cumming. Dated August 10. 1s. 1d. Has for its object the electrically supplying or selling of books, stationery, photographs, cards, tobaccos, confections, liquids, or any other articles or substances contained in the machine. 8 claims.

11749. "Improvements in the manufacture of carbons for incandescent electric lamps." J. S. Sellon. Dated August 15. 8d. Claim:—In the manufacture of carbons or filaments for incandescent electric lamps, the employment of a furnace or heater in which "heavy oil" or petroleum, or other suitable oil or coal gas or other suitable heating gas is employed, together with a blast of air or steam, with or without the addition of oxygen.

18091. "Improvements in electro-motors." W. ALDRED. Dated December 11. 8d. Consists of a metal disc of any required dimensions, on which are mounted one or more electro-magnets arranged in a circle. Through the centre of the disc and the centres of the magnets is placed a shaft, which is supported by two bearings where it leaves the disc. Between the two bearings is placed either a cog or chain wheel, or a pulley and belting, which wheel or pulley is geared or belted on to another one, on a corresponding parallel shaft. Opposite the discs and magnets is placed another disc with a similar number of electro-magnets, with the same arrangement, having the magnets toward each other. The shaft is continued through the centres of the disc and magnets, continuing it through the centres of the other disc and magnets. This end of the shaft outside the disc is also supported by two bearings. Between these two is placed a cog, or chain wheel, or a pulley and belting, which is connected to another cog, or chain wheel, or pulley and belting on the aforesaid corresponding parallel or shaft by an intermediate wheel or pulley. This parallel shaft runs the entire length of the machine, and on it is placed a pulley, or cog, or chain wheel for transmitting the motion for any useful purpose. 4 claims.

CORRESPONDENCE.

Automatic Electric Railway Lamps.

In your issue of July 5th I notice that you give a description of a new automatic lighting lamp for use in railway carriages, &c., and mention it as being one of the latest applications of the coin-freed principle.

This idea is scarcely new, as I have been experimenting with apparatus of this description for the last two years, and have made several forms of automatic lamps with clockwork timing arrangements; I have made no secret of the fact, and a large number of my friends have seen the machinery I have made at different times, and suggested various improvements.

After many experiments, however, I came to the conclusion that clockwork was not the best arrangement to use, on account of its liability to get out of order through the jolting during travelling and the probable rough usage to which the apparatus might be subjected to by unskilful hands, such as railway porters, &c. Also when batteries were used in close contiguity to the apparatus every one knows what would happen.

I therefore turned my attention in another direction, and the provisional patent you noticed on March 29th, 1889, No. 4,530, was the result. In this arrangement I used no clockwork, and the controlling arrangements are the simplest imaginable.

The penny is dropped into the apparatus, a handle half turned, and the light immediately shines forth, and without any arrangement of clockwork trains, springs, &c., the time is controlled and the light goes out at the end of half an hour.

An advantage I can claim which perhaps could not be so easily managed by clockwork is, that I can arrange my apparatus to burn any time from two minutes to say 10 hours by one half turn of the handle.

I should have published a description of my invention earlier, but I considered the clockwork arrangement too unreliable for general use, and therefore withheld the description until I should have the lamps working on my latest principle.

I may add that there has been a working model of my automatic lighting lamp at Messrs. Wheatley Kirk, Price & Goulty's offices since the filing of my provisional patent in March, and although it is somewhat roughly made, it works admirably.

H. J. Dowsing.

July 10th, 1889.

King Brown and Company v. Anglo-American Brush Company.

Your article noticing the decision of Lord Trayner in the above action will lead the casual reader to the conclusion that the Brush Company had scarcely a fair chance, and that the Pursuers, apart from any merits of their case, were saved by Mr. Graham Murray. Allow me to state that the Brush Company's case was most ably got up and reflected the greatest credit on Mr. Sellon, who had charge of the case. They had Mr. Mackintosh, Dean of Faculty, and Mr. Jamieson, and at the trial or proof Mr. Moulton, Q.C., and Mr. Graham were sent from London to assist, Mr. Moulton suggesting most of the cross-examination of pursuers' witnesses.

The Brush Company would not have lost their leading counsel had they not unduly delayed the commission sent to examine Mr. Brush in America. In this they were "hoist with their own petard," Mr. Jamieson, nevertheless, made an exceedingly able defence.

While you cannot speak too highly of Mr. Murray's ability as a scientific advocate yet it must not be forgotten that while he did the entire work in examining and cross of witnesses and speech before Lord Trayner, yet he was most ably assisted by Mr. Dickson and Mr. Daniel, the latter of whom, a doctor of science, contributed largely to the successful result.

It is not often that a case of such importance is fought by counsel all of whom were selected from the junior bar. Among the witnesses for the pursuers it is only right to mention Mr. Jas. Swinburne as having been of the greatest assistance to Mr. Murray in cross as well as to the pursuers in the preparation of their case.

The success in the action is also largely due to the admirable appearance of Mr. Varley in the witness box, and Lord Trayner's remarks as to his evidence are most complimentary, which is all the more gratifying as an attempt was made by the Brush Company to discredit him by mud throwing at the close of his cross-examination after several ineffectual attempts had been made to shake his evidence. Indeed but for this mud throwing it is doubtful whether the sketch (No. 40) from Mr. Varley's pocket book would have been allowed in evidence, and Lord Trayner remarked, on the question being raised before counsels' speeches, that "he had some doubts at the time (of proof) about allowing the sketch to be put in, but he had none now, as attempts had been made to discredit the witness."

A. B. Brown.

Marienbad, *July 2nd*, 1889.

The Compound-Winding Case.

Your lively writer who professes to report upon the proceedings before Lord Trayner, on page 2 of your present issue, has taken a poetic licence with his facts. On the occasion of giving evidence before the court I was handed sundry sheet diagrams, prepared I know not by whom, concerning which I was both examined and cross-examined. "He hung the walls with coloured charts and maps" is not an accurate way of stating that sheet diagrams were handed up to the witness in the box. The "long pointer" is equally the product of unrestrained imagination.

Whilst I am putting pen to paper will you permit me to add that my attention has been drawn to a paragraph, on page 674-5 of your issue of June 14th, wherein it is implied that I have an interest in one of the competing lighting companies; that having such personal interest I cannot take an unbiassed or untrammelled view; that I have advocated a policy of monopoly in electric lighting. Knowing how adverse your journal is, not only to all controversial correspondence and to insinuations which have a personal bearing, but also to all anonymous comments, I content myself with modestly but emphatically denying each of the three points of implication.

Silvanus P. Thompson.

July 5th, 1889.

[Readers will not fail to observe that the latter portion of our esteemed correspondent's letter is, as the late Artemus Ward would have said, "Writ sarkastic."—EDS. ELEC. REV.]